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1	1.1 Background and Context	2	For the reasons detailed in this Submission, the application for approval as submitted is materially deficient with regard to the identification and mitigation of likely significant impacts, which are matters of the utmost concern for Trinity.	TCD's position is noted, however, TII disagree with this position as outlined in the responses to the queries below.
2	1.1 Background and Context	2	Whilst the EIAR clearly identifies "significant" and "negative" impacts on Trinity's educational and research facilities, it is also acknowledged in the EIAR itself that the mitigation measures proposed in the design will not adequately protect the identified sensitive receptors. In this regard, the EIAR states, inter alia that: *"**TII will continue to work with Trinity** with respect to provision of appropriate mitigation to protect sensitive equipment at locations **that would still require some protection** based on this revised alignment." (EIAR Section 7.7.9) [Emphasis added]*	This is considered to be a misinterpretation of the position presented in the EIAR. TII are confident that the proposed mitigation measures will address the identified impacts (having regard to Groundborne Noise & Vibration and Electromagnetic Interference). The text referenced refers to the fact that mitigation will be required at the location of some equipment and as such will have to be determined in consultation with TCD.
3	1.1 Background and Context	2	The Arup assessments of the proposed alignment and design have identified significant information gaps, omissions, errors, reliance on reference to mitigation measures that are asserted to have worked elsewhere without any reference to context or circumstance for comparison, and reference to future engagement with Trinity to design mitigation measures in respect of which the EIAR and submitted documents provide no certainty, or even an acceptable level of confidence, can be effective. In the latter respect, it is well- established that it is impermissible to devise mitigation measures after development consent is granted. The EIAR is materially inadequate and qualitatively deficient in this regard, and those inadequacies and deficiencies have significant consequences for Trinity's existing teaching and research and development facilities and thus the application documentation fails to adequately identify, describe and assess the likely direct and indirect significant effects of the MetroLink project on Trinity	The reference to design of mitigation measures after the grant of RO is to matters of detail only. TII have consulted with TCD on the proposed Project since September 2018, where the first request for data of sensitive equipment on the campus was requested. This was followed by numerous email requests for data. The assessment presented in the EIAR (for Electromagnetic Interference (Chapter 12) and Groundborne Noise & Vibration (Chapter 14) is based on data requested from and provided by TCD. Furthermore, TII have presented the outputs of assessments to TCD on a number of occasions commencing with a presentation of data on 25/3/21. This presentation clearly outlined the potential effects of the proposed Project on TCD equipment (with and without mitigation). On no occasion prior to this submission have TCD identified that there were gaps in data provided to MetroLink by TCD. TII note that the EIAR Appendix A7.10 Trinity College - Alignment Options Assessment, which contains details of the assessment of potentially affected equipment within TCD buildings and assessed mitigation requirements, has been previously shared with TCD. Having regard to the requirement to demonstrate that the mitigation measures proposed will be effective, TII and their consultants have met with TCD presenting this position and evidence of where the proposed mitigation measures have worked at sensitive locations around the world (Refer to the Response (7)). Please also have regard to Section 5.6.4 of Appendix A7.10 of the EIAR, which presents examples of where active cancellation has been an effective mitigation measure. As outlined in this document and in previous consultations with TCD, Compliance Engineering Ireland (CEI) have global experience of utilising this proposed technology. Furthermore Rupert Thornley-Taylor is a global leading specialist in Groundborne Noise & Vibration from rail systems and has identified the proposed mitigation measures based on experience and has also modelled the outputs of the implementation of both Gerb springs and isolated base slabs to demonstrate the effectiveness of these proposals to sufficiently mitigate the groundborne noise & vibration levels

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			likely direct and indirect significant effects of the MetroLink project on Trinity.	isolated base slabs to demonstrate the effectiveness of these proposals to sufficiently mitigate the groundborne noise & vibration levels. In conclusion, the assessments presented in Chapter 12 and Chapter 14 of the EIAR have been undertaken based on the information requested from and received from TCD. The analysis has been undertaken using this data (from TCD) by competent and global leaders in their fields (in the preparation of both Chapter 12 and Chapter 14) and is not inadequate or deficient as we will demonstrate throughout this response.
4	1.1 Background and Context	2	The significant uncertainty in respect of the availability and efficacy of potential mitigation measures also has significant implications for the future provision, upgrade and enhancement of equipment and research programmes in the affected buildings. In this regard, the proposed alignment, together with the wholly inadequate mitigation measures identified, have significant potential to constrain or sterilise Trinity's existing and future core academic and research activities on the eastern part of its campus.	There is no uncertainty in respect to the availability and/or efficacy of the proposed mitigation measures. The proposed mitigation measures presented in Section 12.11 of Chapter 12 of the EIAR present the following potential mitigation measures (a) Potential relocation of effected equipment (b) Installation of active cancellation systems or (c) Shielding of labs/rooms using specialised materials designed to attenuate magnetic fields. TII are confident based on the experience presented by CEI (in Section 5.6.4 of EIAR Appendix A7.10) that active cancellation systems will be fully effective to mitigate EMI at all identified equipment at TCD. However, TII have also offered two further options to ensure there is significant scope to reach agreement with TCD. In EIAR Chapter 14, mitigation measures are presented (for the operational phase) in Section 14.5.2. These mitigation measures will entail two primary elements (a) Floating Slab Track and (b) the use of "base-isolated foundation slabs" to support equipment. It is considered that (a) will be sufficient in the vast majority of cases, but should TCD introduce new equipment, there may be a requirement to also consider (b). In conclusion, the implementation of the proposed mitigation measures as outlined in EIAR Chapters 12 and 14 will ensure that there will be no sterilisation of the eastern part of the TCD campus, as suggested.

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5	1.1 Background and Context	2	Based on Arup's assessment of the proposed alignment, and the ineffective nature of the mitigation measures proposed in the EIAR to protect the performance requirements of the affected equipment, the only effective mitigation strategy is based on the following elements; • Trinity's Proposed Mitigation Strategy: Mitigation by design with a localised realignment of the line beneath the Campus, identified on Figure 1.1 below as 'Alignment Option 5', moving the alignment 61.5 m westward of the current proposed alignment; and Further detail and assessment provided by the Applicant, by way of response to a Request for Further Information issued by the Board, in respect of the Mitigation Measures proposed in the EIAR, as supplemented in this submission by Trinity's experts, to demonstrate to the satisfaction of the Board (and Trinity) the efficacy and practicality of those measures based on robust survey data, monitoring, assessment, and evidence of successful comparators, based on the Option 5 Alignment.	The proposed Project design underneath the TCD campus has been assessed for its impacts on sensitive TCD equipment and the EIAR assessments indicate that appropriate mitigation can be provided to all impacted equipment (see Response (4) above). Our assessment indicates that: - the proposed Project alignment with a 350m radius curve from Tara station underneath the TCD campus moves the alignment away from a number of sensitive locations on the campus, therefore reducing impacts on some items of sensitive equipment when compared to the 400m radius curve, which is the project standard; - for remaining equipment which is still assessed as impacted by EMI effects, the proposed installation of Active Cancellation is proposed by TII to provide appropriate EMI protection. - as outlined in EIAR Chapter 13, the inclusion of "Gerb type" floating slab track would be effective at mitigating groundborne Noise and Vibration at the majority of sensitive equipment locations. The modelling indicated that in the SNIAMS building, at the worst case location, VC-E limits can be achieved, while for the Fitzgerald building, at the worst case, VC-D limits can be achieved. If additional mitigation is required, this would be achieved by the use of "base-isolated foundation slabs". As such, the proposed Project design and mitigation proposals will provide effective mitigation during the operational phase to all known potentially affected TCD equipment. With regard to alternative alignments further away from the TCD campus, requiring tighter radius curves, the EIAR Appendix A7.10 Trinity College - Alignment Options Assessment document provides details of our assessment of a 302m radius curve in lieu of the 350m radius curve adopted in the proposed Project. The key reasons why we cannot accept this proposed reduction in the curve radius (or the further reduction to 260m as suggested in the TCD Option 5) is that the adopted minimum 350m radius curve is the minimum radius that meets the proposed Project operational requirements and provides the appropriate space proofing required at this stage of design. In particular the minimum curve radius of 350m in the tunnel section allows for: - the space proofing for equipment incorporated in the tunnel based on the maximum usual size of known equipment required; - the Dynamic Kinematic Envelope (DKE) for the train design assessed at this preliminary design stage; and - retention of the Infrastructure Manager Reserve (also referred to as the Additional Infrastructure Traverse Allowance) of 200mm as specified for the proposed Project by TII. This allowance is the clearance between the limit (dynamic gauge) and the nominal (structural) gauge and is the same as that adopted by other international metro/railway operators. Retention of this allowance is necessary at this early stage of the proposed Project to facilitate and not restrict future operators design proposals and train provision and thus maintain effective procurement competition. Reducing the curve radius, to 302m (as assessed in EIAR Appx A7.10) or below, would increase the DKE profile such that it would be hard against the tunnel infrastructure, removing the current 200mm reserve (M3b, Additional Infrastructure traverse allowance). To regain the required reserve would require a permanent speed constraint of 60kmph in this section, compared to the TII operational design requirement of 80kmph, and which would also reduce project economic benefits. The TCD proposed Option 5, incorporating a further reduction in the curve radius to 260m, would similarly impact the tunnel space proofing and further locally reduce the design speed to 55kmph. Furthermore, it is generally accepted in the railway industry that lower radius curves can introduce greater rail/wheel interface issues, with increased noise, vibration and wear impacting passenger comfort and maintenance requirements. A reduction in radius would thus increase these risks of creating a poorer operational environment at this location.

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6	1.1 Background and Context	3	A spreadsheet is attached at Appendix C to assist the Board in understanding the interactions between the sensitive equipment and receptors, the route alignment options and the proposed mitigation measures. The spreadsheet identifies all sensitive equipment, the 'as submitted' route alignment with EIAR mitigation, the alternative route alignment options with mitigation, and alignment Option 5 with EIAR mitigation. The spreadsheet uses a colour coded system to identify the predicted EMI and vibration impacts on all elements of sensitive equipment. The colour coding demonstrates the increasing confidence in the efficacy of mitigation the further west the alignment is moved. In this regard, Trinity's Proposed Mitigation Strategy is the only approach that provides an acceptable level of confidence that significant impacts will be alleviated.	See Response (5) regarding the use of tighter radius curves as proposed by TCD. In addition, as outlined in Chapter 12 of the EIAR, Active Cancellation (or shielding) would be effective in mitigating any effects on the identified sensitive equipment. As outlined in EIAR Chapter 13, the inclusion of "Gerb type" floating slab track would be effective at mitigating groundborne Noise and Vibration at the majority of sensitive equipment locations. The modelling indicated that in the SNIAMS building, at the worst case location, VC-E limits can be achieved, while for the Fitzgerald building, at the worst case, VC-D limits can be achieved. If additional mitigation is required, this would be achieved by the use of "base-isolated foundation slabs".
7	1.1 Background and Context	3	Based on the information submitted with the application, it is the opinion of Trinity's technical experts that the Applicant has failed to demonstrate that it is proposed mitigation measures are capable of effective implementation. In particular, the mitigation measures proposed in the EIAR are qualitatively deficient in that they lack substantive validation by robust survey data, monitoring, assessment and evidence of successful comparators.	TII have in a number of meetings held with TCD, provided examples of where the proposed EMI mitigation measures have been effectively utilised. Furthermore please also have regard to Section 5.6.4 of Appendix A7.10 of the EIAR where it is outlined that Active Cancellation is an industry recognised and cost-effective method of providing appropriate EMI protection to sensitive equipment when protection at source is either not feasible or desirable. As identified to TCD previously, CEI (TII's specialist consultants) have identified Active Cancellation is a viable option to address residual EMI effects on TCD equipment. This is based on their practical experience gathered from projects including: 1. Neils Bohr Building, Copenhagen, Denmark (SEMs) 2. Qatar Science and Technology Park, Doha 3. Francis Crick Institute, London (NMRs, SEMs) 4. Irvine Materials Research Institute, California (TEMs) – used in combination with shielded room 5. Royal Hospital Melbourne, Australia (Linac) - Ongoing. In terms of Groundborne Noise and Vibration, it has been identified (by modelling) that mitigation measures in the form of floating slab track incorporated into the design will remove any significant effects during the operational phase for the SNIAM building and the Fitzgerald building as identified in Response (6).

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8	1.1 Background and Context	3	In the event that the Applicant fails to demonstrate that effective, proven mitigation measures can be implemented, then Trinity will be left in the position where it requests that the Board should refuse consent, or decide to terminate the MetroLink at a point north of Trinity's Campus[4], having regard to the likely significant adverse, permanent and unacceptable impacts on the University's sensitive equipment, its established and future research facilities, its students, researchers and staff, and its global status and funding. (Footnote: [4] It is noted that the termination of the MetroLink further north echoes one of the observations made by the Major Projects Advisory Group of the Department of Public Expenditure & Reform (Jul-22) which provides that 'the rationale for extending the preferred scheme to Charlemont is seen as being strategically weak, given the additional costs involved and the duplication of the LUAS Green line which also provides a public transport service to these areas of the city';)	An Bord Pleanala should have full regard to the fact that TII have engaged fully with TCD, having presented outputs of both the EMI and noise and vibration assessments to TCD, in addition to proposed mitigation measures in advance of lodging the RO application. For the purposes of the EIAR and the RO application, TII have presented these proposed mitigation measures and are confident based on the global experience of our specialists that the proposed mitigation measures will be effective. The TCD position that active cancellation will not mitigate EMI/EMC is contry to the information that TII previously presented to TCD and that included in the EIAR. Furthermore, TCD have provided no evidence as to why it is considered that the mitigation measures will not be successful. With regard to termination of the proposed Project before the section under the TCD campus, the MPAG comments were made in the context of the financial approvals for the project which are a function of the Government and not An Bord Pleanála. The conclusions of the MPAG were known to the Government when it approved the Preliminary Business Case for the project. As regards consideration of terminating the alignment north of TCD, this would be a material contravention of the NTA's GDA Transport Strategy 2022-2042, which proposes that MetroLink terminate at Charlemont. In addition, the alternative of terminating MetroLink at St. Stephen's Green compared to Charlemont is considered in EIAR Appendix A7.9, Terminus Station at Charlemont compared to St. Stephen's Green. The main conclusions of this assessment would also apply equally to a termination of the line further north (at Tara Street for example), including: • future proofing of the Green Line connection • bypassing of the capacity constrained Luas on-street running section • supported by the Transport Strategy for the Greater Dublin Area 2022-2042 • all potential future connectivity options enabled • additional fare/revenues collected with a favourable Cost Benefit ratio likely.
9	1.1.1 Objectives of this Submission	5	this submission is intended to provide a basis for the Board to issue a Request for Further Information inviting the applicant to submit a revised EIAR, revised plans and all necessary assessments, in respect Trinity's Proposed Mitigation Strategy	Noted, however see Response (5).
10	1.1.1 Objectives of this Submission	5	The submitted Arup Reports provide detailed assessments of the impact of the proposed alignment and the EIAR mitigation measures on Trinity's equipment and faculties. Indeed, it should be noted that the Arup assessments are based on information supplied by Trinity to the Applicant at the pre-application consultation stage. That information includes details of the location and type of all affected equipment and facilities and information in respect of the applicant's assessment of likely and significant impacts and the proposed mitigation measures.	Noted. TCD do not note any omissions or deficiencies in the data provided during consulation. See also Response (3)

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11	1.1.1 Objectives of this Submission	5	As noted, the Arup assessments conclude that there are significant omissions and errors in the assessment of potential impacts, that the potential efficacy of the proposed mitigation measures are inadequate and/or have not been demonstrated by reference to monitoring, data and relevant comparators.	TII completely refute this TCD position. There are no significant errors and omissions in the EIAR assessments. Specific responses to these charges are provided in responses to items below. TCD in their submission refer to uncertainty with regard to the effectiveness of mitigation measures. However no evidence or information is presented that supports this position and as outlined in Responses (6), (7) and (37), TII have already presented TCD with evidence and information to support the proposed mitigation measures.
12	1.1.1 Objectives of this Submission	5	It is imperative that the Applicant provides the significant additional information in respect of proposed mitigation measures identified in this submission for the following reasons: 1. To enable an assessment by the Board of the efficacy of proposed mitigation measures that are reasonable, feasible and that can be implemented. 2. To clearly detail and articulate in the EIAR the proposed mitigation measures to which the Applicant is committing and will be obliged to implement at its own cost in the event that the project proceeds. 3. To clearly detail monitoring that will be undertaken by the Applicant for the duration of construction and operation phases, and further mitigation measures that may be necessary in the event that the mitigation measures are not effective. This submission and the accompanying reports provide the technical evidence base for the Board to invite the applicant to submit a revised EIAR, plans and assessments in respect of the Trinity's Proposed Mitigation Strategy. This submission also itemises the information that the Board is invited to request from the Applicant for the purpose of satisfying items 1 to 3 above.	TII have provided a level of detail on proposed mitigation measures and monitoring requirements that are sufficient to demonstrate that the magnitude of impacts can be reduced to residual impacts described in the EIAR. Please refer to other Responses provided here as clarification to the technical issues raised and specific mitigation proposed or incorporated as part of the RO Application. As outlined in EIAR Chapter 14, Section 14.5.2 TII are happy to work with TCD to work through detail of the implementation of the proposed mitigation measures (and monitoring) at equipment locations.
13	1.1.1 Objectives of this Submission	5	Trinity's Proposed Mitigation Strategy presented in this submission identifies possible mitigation measures, in addition to the measures identified in the EIAR, that are necessary to protect the equipment and to avoid unacceptable impacts on the University's educational and research facilities, its students, researchers and staff, and its global status and funding. It is requested that TII is invited to assess these mitigation measures, based on the information available and supplied by the University and Arup, and to incorporate those mitigation measures into the EIAR so that they are legally binding, in the event that the Board grants development consent. The revised EIAR and design details must demonstrate to the satisfaction of the Board that the mitigation measures are reasonable, feasible, will be effective, and will be the responsibility of Til to implement.	Please refer to Response (5) above regarding TCD Option 5.

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14	1.1.1 Objectives of this Submission	5	As noted, this submission presents evidence for Option 5 as a reasonable alternative to reduce significant impacts that should be considered. Option 5 has been considered by Trinity's experts and there is no apparent planning, technical or engineering reason which would preclude the Board from considering this route option. In order to do so, however, the Board should request TII to provide all necessary information to enable a complete assessment of this route alignment. This is further addressed in Section 4.1	Please refer to Response (5) above regarding TCD Option 5. EIAR Appendix A7.10 provides the TII assessment information for alternative alignments past TCD. This assessment indicated that an alignment with a radius of 302m (Option 4) was not acceptable to TII for a number of reasons (ref section 6.1) and the TCD submitted Option 5 with a radius of 260m would further exacerbate the noted concerns. These planning, technical and engineering constraints for track radii less than 350m have been identified to TCD in consultations and as such are not further addressed in their submission.
15	1.1.1 Objectives of this Submission	6	As noted, in the event that the Applicant does not demonstrate to the satisfaction of the Board that effective mitigation measures can be implemented at its expense, Trinity reluctantly requests the Board to refuse consent, or to terminate the MetroLink at a point North of Trinity's Campus, having regard to the likely significant adverse, permanent and unacceptable impacts on the University	TII have engaged with TCD as outlined in Response (3). During these engagements TII have provided TCD with information and evidence with regard to where the proposed mitigation measures have been implemented successfully (ref EIAR Appendix A7.10, section 5.6.4). TCD specific concerns and TII response regarding the proposed mitigation are as follows: (1) TCD claim Active cancellation is not an appropriate mitigation measure. Refer to TII Response (7) which outlines it is widely used to mitigate EMI/EMC and has been used in all of the institutions listed. (2) TCD claim Floating Slab Track (Gerb springs) is not a viable mitigation measure, without any evidence provided for this assertion. Refer to TII Response (37) which notes where this system has been successfully used. TII are confident that both of these proposed mitigation measures can be successful and are happy to work with TCD to implement these measures.
16	1.3 Contributors to this Submission	6	This submission has been informed by the following Reports, which are referenced throughout this document and are attached as appendices: • A Review of Alignment and Associated Tunnelling Matters prepared by CECL Global (Appendix D) • MetroLink Impacts - Electromagnetic Interference (EMI) prepared by Arup (Appendix E) • MetroLink Impacts - Vibration Assessment prepared by Arup (Appendix F)	Noted - no response required.
17	2.1 Details of Buildings, Departments, Faculties and Equipment Impacted	7	Approximately 312m of the alignment as presented in the Draft Railway Order documentation (Option 2) passes directly under the eastern side of the Trinity Campus.	Noted - no response required

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18	2.1 Details of Buildings, Departments, Faculties and Equipment Impacted	7	The Departments, Faculties and buildings impacted by the construction and operation of the proposed alignment are listed below and identified on Figure 2.1 overleaf. Table 2.1 on the following pages itemises and details the affected equipment located in those buildings, and its purpose and importance to the relevant Departments', Faculties' or Institutes' teaching and research activities. The affected buildings identified on Figure 2.1 overleaf are: •The Option 2 alignment passes directly under the Simon Perry Building and The Pavilion and Moyne Institute of Preventative Medicine. •The Botany Building and Fitzgerald Building are located immediately east of the Option 2 alignment. •The Sami Nasr Institute of Advance Materials and the Lloyd Institute are immediately east of the Botany and Fitzgerald buildings. The closest element of sensitive equipment is 58 m from the Option 2 alignment. •The Chemistry Building is to the east of the Option 2 alignment. The closest element of sensitive equipment is 45 m from the alignment. •The Panoz Institute is immediately east of that building. The closest element of sensitive equipment is 115m from the Option 2 alignment. •The Centre for Research on Adaptive Nanostructures and Nanodevices (CRANN) is approximately 98 m to the north-west of the Option 2 alignment.	TII acknowledge that the proposed alignment passes in proximity to the said buildings. However it should be noted that the assessment of Electromagnetic Interference (Chapter 12) and Groundborne Noise & Vibration (Chapter 14) have assessed the potential impacts on these buildings and particular equipment within them and as outlined in these chapters have identified that the potential impacts on the buildings and equipment can be mitigated. The exception to this position is during the TBM progression whereby there is potential for exceedances of groundborne noise and vibration during the short progression of the TBM under or close to any single location. The duration of this impact at any single location will be so limited in duration that TII are confident that these impacts can be mitigated by way of engagement with TCD around the management of equipment during this short period, as already discussed with TCD. See also Response (52).
19	2.1 Details of Buildings, Departments, Faculties and Equipment Impacted	14	The assessments undertaken by Arup (and to a lesser extent, the assessments in the EIAR) establish that there is a high probability of significant impacts on the operation of the equipment during the construction and operational phases of the proposed MetroLink development. Damage to, or the inability to reliably use, the equipment would result in severe disruption to, and (in a worst case scenario) a complete shutdown of, many current teaching and research activities, including world leading research being undertaken by PhD students and post-Doctoral researchers. Furthermore, negative impacts on the ability to reliably use equipment would result in the discontinuation of grants and an inability to secure new grants for further research and development. The loss or revenue from external sources would seriously impact the viability of many of the University's research activities 5.	Without the proposed mitigation incorporated in the proposed Project then the assessment indicated that there would be some significant impacts on particular equipment. However, the proposed mitigation measures for Groundborne Noise & Vibration and EMI is assessed to remove these significant impacts.

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20	2.1 Details of Buildings, Departments, Faculties and Equipment Impacted	14	The EIAR does not adequately reflect the range and extent of vibration sensitive locations and facilities that would potentially be affected, both by construction and operation of MetroLink; only a small sample of the impacts are described in Chapter 14 of the EIAR. With regard to the construction phase of the project, in particular, the disruption impacts are anticipated to be widespread and more difficult to mitigate than operational stage impacts. Construction impacts will arise from the tunnel boring machine (TBM) and from any temporary construction railway. Vibration from the TBM is predicted to impact all facilities and may also cause adverse ground borne noise impacts in some spaces. Vibration from any temporary construction railway would be at least as high as that from the unmitigated operational railway, although there would be fewer movements per day. During construction, disruption to Trinity's activities would occur for several months. The only mitigation proposed in the EIAR is for Trinity to "work around" the tunnelling programme, which would significantly disrupt Trinity's activities. Furthermore, the risks from blasting works for Tara Station have not been reported or assessed.	TII do not accepted that the EIAR does not adequately reflect the range and extent of vibration sensitive locations and facilities. Please note that TII have engaged with TCD since September 2018 in order to define the locations of sensitive equipment at TCD. Based on the information made available from TCD, a programme of baseline vibration surveys were undertaken at the eight separate sensitive locations identified in the EIAR Chapter 14, Groundborne Noise & Vibration, Table 14.21. The locations and equipment assessed are those that have been identified by TCD to MetroLink and the locations are consistent with those presented in Table 2.1 of the TCD submission, all of which have been assessed. However, in order to undertake building specific modelling, TII was restricted to undertaking this modelling for buildings to which TCD provided details (i.e. Fitzgerald, SNIAM). However, it is important to note that these buildings are a worst case as they are adjacent to the MetroLink alignment. The statements put forward by TCD that "Damage to, or the inability to reliably use, the equipment would result in severe disruption to and in a worst case scenario a complete shutdown" is inaccurate and unnecessarily alarmist. As outlined in the EIAR, there will be potential for a short term impact (a number of days) at each location during the construction phase due to the advancement of the TBM which will result in exceedances of groundborne Noise and Vibration impacts. As outlined in EIAR Chapter 14, Section 14.5.1.1, mitigation measures will be implemented which have specific reference to TCD and this is "With regard to vibration effects on the use of sensitive equipment, there is potential to plan the passage of the TBM during weeks when critical use of the equipment can be avoided. The programme for the TBM will be planned by the contractor. Consultation will be undertaken with TCD as soon as this programme is available to ensure that sensitive research operations on the campus do not coincide with the passage of the TBM". A temporary construction railway has not been proposed to be used during the construction phase. Blasting during construction has been assessed within the EIAR, with predicted vibration levels from blasting given in the EIAR Chapter 14, Table 14.34, for locations that are in close proximity to blasting activities. As the TCD campus is outside of the 1 mm/s contour from blasting, as shown in EIAR Figure 14.4, values for TCD buildings are not included in this table. With predicted levels of blasting of less than 1 mm/s no potential adverse impacts are anticipated from blasting at TCD buildings.

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21	2.1 Details of Buildings, Departments, Faculties and Equipment Impacted	14	There will be limited impact from an EMI, EMF or stray current perspective likely during the Construction Phase of the proposed Project. However, sensitive equipment assessed by Arup would be affected by vibration during the construction phase and impacts require to be properly assessed and demonstrably effective and feasible mitigation measures proposed. The operational phase of MetroLink, as currently proposed, is predicted to impact the performance of sensitive equipment within the Departments and Institutes identified in Table 2.1, above.	For clarity the assessment presented in Chapter 12 of the EIAR identifies that there is no potential for environmental effects arising from EMI, EMF or stray current during the construction phase of the proposed project (Refer to Section 12.6.1 of EIAR Chapter 12). Potential effects from vibration during the advancement of the TBM are properly and fully assessed in the EIAR. Please refer to the results presented in Section 14.4.32 of Chapter 14 of the EIAR and in Appendix A14.5 of the EIAR, where vibration results are provided at every building overlying the alignment. The mitigation measures proposed in Section 14.5.1.1 of Chapter 14 of the EIAR are the only effective mitigation measures that can be used to mitigate the effects of the advancement of the TBM on each location of sensitive equipment. i.e. advanced consultation to ensure that the sensitive research operations do not coincide with the passage of the TBM. Also refer to Response (20). During the operational phase, groundborne noise levels are presented in Table 14.44 of Chapter 14 of the EIAR where no significant impact is identified on a select number of TCD buildings. For groundborne vibration, Table 14.46 in Chapter 14 of the EIAR identifies the potential for exceedance of the VC-E threshold value for the Trinity College - Chemistry Building, the Sami Nasr Institute and the Moyne Institute. In order to mitigate these impacts, floating slab track is proposed under TCD as outlined in EIAR Table 14.47, which sufficiently reduces vibration to remove this potential adverse impact. With the inclusion of this mitigation measure for these closest buildings, those buildings that are further away will also be effectively mitigated.
22	2.1 Details of Buildings, Departments, Faculties and Equipment Impacted	15	During operation, with the track system proposed for other locations, the EIAR identifies that there would be significant risk to Trinity's equipment from vibration. EIAR Chapter 14 states that the impacts at Trinity will be fully mitigated by track design and by additional local mitigation where needed. A complex track support system is proposed by TII that Arup's analysis indicates could address the majority of significant effects, however, there are uncertainties about the viability of the proposal. The predictions of vibration impacts at low frequencies are uncertain due to uncertainties in the input parameters. Furthermore, the track support system proposed would result in track deflections much greater than normal or proven for floating slab track, which has not been described or assessed in the EIAR.	It should be recalled that the vibration measurements carried out on sensitive equipment at Trinity College in the current situation already exceed the vibration specifications required by the TCD for such equipment. The floating slab track solution incorporated by MetroLink offers the best attenuations over a wide frequency range and if the concern is at low frequencies, increasing the stiffness is not appropriate. See also Response (37).
23	2.1 Details of Buildings, Departments, Faculties and Equipment Impacted	15	The proposal in the EIAR to mitigate residual significant effects at the receptor (sensitive equipment) through the use of base-isolated foundation slabs would not be practicable for all equipment and buildings, especially for locations where equipment is not on a ground floor or basement level slab. It cannot, therefore, be concluded that all vibration risks to Trinity's equipment would be addressed. Furthermore, provision of sufficient and adequate mitigation at any affected items of equipment would be disruptive and/or impracticable.	The modelling has indicated that if equipment is located on floors above the ground floor or basement, there will be no requirement for further mitigation other than the floating slab track to be incorporated through this section of the route. This is because buildings are more prone to increased vibration as you move up floors/levels and existing levels of vibration are likely to be signficantly in excess of any any vibration generated by MetroLink. See also Responses (4) and (6).

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24	2.1 Details of Buildings, Departments, Faculties and Equipment Impacted	14	Trinity has considered an alternative potential mitigation option that would involve the relocation of sensitive equipment. This option is not viable or practical for the reasons identified below: •There is no current viable relocation option available on the Campus, in terms of the areas required to accommodate the relocated activities. •The damage to Trinity's reputation as one of Ireland and Europe's leading research universities and the consequential damage to Ireland's overall reputation within the European research community which would arise from such disruption and uncertainty •The prohibitive cost of relocating equipment, particularly equipment currently accommodated in specially designed and purpose-built structures, buildings and parts of buildings. •The time and cost of securing suitable alternative premises and the associated costs in their renovation and fit-out to provide acceptable facilities. •The time required to decommission and recommission would be long and disruptive	Noted, however the EIAR assessments as noted in other Responses indicate that the proposed mitigation will address assessed impacts on sensitive equipment and relocation will not be necessary.
25	3.1 omissions and Errors in the EIAR Assessments	16	The assessments included in the EIAR have failed to identify, describe and assess the range and nature of sensitive equipment likely to be impacted.	This is not the case. Please refer to Response (26) and (38) in regard to Groundborne Noise & Vibration and Response (29) in regard to EMI effects..
26	3.1 omissions and Errors in the EIAR Assessments	16	With regard to ground borne noise, the EIAR identifies only three sensitive receptors on the Trinity campus for assessment- the Chemistry Building Extension, SNIAM and the Moyne Institute (see EIAR Ch 14, Section 14.3.1.4 and Table 14.18). The EIAR does not accurately identify or describe the range and extent of locations and facilities that would potentially be affected by ground borne noise during both the construction and operation of MetroLink.	EIAR Chapter 14 Section 14.3.1.4 and Table 14.18 presents examples of receptors that are considered to be representative of all receptors in the area of AZ4 and in the vicinity of the project. A larger list of receptors that have been assessed together with prediction results are presented in Appendix A14.5 Groundborne Noise and Vibration and Blasting modelling results. The three buildings included within the Chapter 14 were selected as representative of the closest Trinity College buildings to the tunnel route. The identification of the closest buildings and mitigation proposals for those buildings will result in the removal of potential adverse impacts for buildings that are further away from the tunnel route.

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27	3.1 omissions and Errors in the EIAR Assessments	16	Section 14.4.1.7 of the EIAR states: "with regard to vibration effects on sensitive equipment, Criterion VC-E will occur within a distance of 250m either side of the tunnel centreline, and during the passage of the TBM there is a potential significant effect on the operation of sensitive equipment". However, no predictions are provided for the many other facilities within the 250m wide corridor and in particular those identified in Table 2.1. The EIAR assessment of predicted impacts during the passage of the TBM only tabulates predictions for the three buildings identified in Table 14.18 [Chemistry Building Extension, SNIAM and the Moyne Institute], EIAR Table 14.21 provides a much more extensive list of buildings and facilities within the 250 m corridor. EIAR Appendix A14.5 provides a table of all vibration modelling results and shows the whole of the Trinity campus to be exposed to vibration above VC-A, which is above the criteria for all Trinity's sensitive equipment. As such, there are significant omissions, gaps and internal inconsistencies in the information presented and the assessments undertaken in the EIAR.	The statement relating to a potential significant effect for equipment sensitive to vibration within a distance of 250m of the tunnel centreline establishes that there is a potential impact for sensitive equipment within this corridor, as such predictions for specific locations are not considered to be necessary. It should also be noted that calculation results for VC during the TBM passage are included for many additional receptors close to the MetroLink alignment in EIAR Appendix A14.5, Groundborne Noise and Vibration Blasting Modelling Results, in addition to the results presented in EIAR Table 14.18. The three buildings included within the EIAR Chapter 14 were selected as representative of the closest Trinity College buildings to the tunnel route. The identification of the closest buildings and mitigation proposals for those buildings will result in the removal of potential adverse impacts for buildings that are further away from the tunnel route.
28	3.1 omissions and Errors in the EIAR Assessments	16	Having regard to operational groundborne noise and vibration, EIAR Section 14.2.5.4.3 states: "at Trinity College Dublin examples of the most sensitive cases were fully modelled in three dimensions" . Details of the modelling for each building have not been included in the EIAR and Table 14.44 provides predicted groundborne noise levels for only three buildings (Chemistry Building, Sami Nasr Institute and Moyne Institute).	The EIAR does not include detailed 3D modelling reports of groundborne vibration for the buildings. The buildings reported (Chemistry Building, Sami Nasr Institute and Moyne Institute) were selected to be representative of the closest buildings to the tunnel route and were considered adequate.
29	3.1 omissions and Errors in the EIAR Assessments	16	In terms of sensitivity to EMI, the refined list of equipment identified in EIAR Section 12.8.4.9 is generally consistent with the sensitive receptors identified by Arup and is considered to be adequate for the purpose of assessment.	With the exception of the SEM Zeiss Sigma 300, (see Response (38)), the list provided in the Respondent's submission (Appendix C) does not highlight any additional equipment that would be considered at risk of impact from EMI from the proposed development.

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30	3.1 omissions and Errors in the EIAR Assessments	16	In addition to the above omissions and deficiencies, the following further omissions and deficiencies in the EIAR have significantly constrained an assessment of the magnitude of likely significant impacts and the need for or efficacy of proposed mitigation measures:	See Responses below.
31	3.1 omissions and Errors in the EIAR Assessments	17	• Appendix A7.10, Trinity Alignment Options Report, should contain detailed Horizontal / Vertical Alignment Detail drawings for each of the 4 no. alternative alignment options considered (Appendix E of that Report). These have been omitted contributing to the difficulty in assessing the relative merits of each of the alternatives considered.	It is correct that the EIAR appendix does not contain the additional technical information referenced. TII are happy to provide additional information to TCD as required.
32	3.1 omissions and Errors in the EIAR Assessments	17	• EIAR Appendix A14.2 provides insufficient detail on rolling stock to facilitate a rigorous swept path analysis for the purpose of determining the potential for a slightly tighter radius curve enabling the alignment to move further westward from the sensitive receptors.	The rolling stock design adopted for the proposed Project to assess the DKE requirements is not based on a specific supplier rolling stock, but has been developed as a generic design at this preliminary design stage to retain the opportunity during procurement for various manufacturers to offer compatible rolling stock. The design has been developed in accordance with EN 15273 Railway Applications - Gauges, Parts 1, 2 and 3 which outline a method to calculate the nominal gauge to implement the design of the infrastructure (the structural gauge) based on an adopted rolling stock static profile. Thus the design approach is based on the use of a theoretical static gauge envelope which is appropriate for a generic configuration of rolling stock. From this, a dynamic envelope for the vehicle was developed and appropriate safety margins applied. A detailed check on the swept path analysis will be carried out in future design stages once train parameters are defined by the supplier based on the design parameters provided. At this stage, TII consider that the proposed 350m radius curve is the best alignment compromise (as the change in lateral acceleration reaches limiting values for passenger comfort) to address TCD concerns; to ensure that the proposed Project is not operationally constrained; and provides sufficient tolerance between the DKE and the tunnel internal furniture to maximise supplier interest in future procurement activities.

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33	3.1 omissions and Errors in the EIAR Assessments	17	•EIAR Section 14.3.2.2, considering vibration surveys at Trinity Buildings, refers to EIAR Appendix A13.5 and states that "full details of survey location, methodologies, parameter definitions and results of the baseline surveys at Trinity" are provided. A summary rather than the full results is provided in EIAR Appendix A13.5.	TII disagree with this assessment. A 47 page report is provided in Appendix A13.5 which provides precise and accurate details of the survey locations, of the monitoring methodology and equipment. It should be noted that, as outlined in Section 2.4 of that report, a summary of results is provided as the full dataset on which the summary is based consists of a significant volume of material which does not add significantly to that provided in the report.
34	3.1 omissions and Errors in the EIAR Assessments	17	• Vibration from tunnel boring has been predicted using the FINDWAVE® numerical modelling method (EIAR Section 14.2.5.2.1), with details of the methodology stated to be presented in EIAR Appendix A14.4. The Appendix only describes the software application to operation of MetroLink and not the construction.	TII acknowledge that EIAR Appendix A14.4 does focus on the operational phase assessment requirements. However, EIAR Chapter 14, section 14.4.1 Construction Phase Impacts, provides an overview of the assessment of groundborne noise and vibration from tunnel boring. Noise and vibration assessment results are provided in table 14.29 and table 14.32, based on use of the Findwave model.
35	3.1 omissions and Errors in the EIAR Assessments	17	• EIAR Chapter 5 provides a detailed description of equipment needed to support the TBM but does not include any detail how personnel and materials such as tunnel lining segments would be transported through the tunnel to the TBM. Assumptions relied upon in EIAR Chapter 14 (Groundborne Noise & Vibration) include that "the TBM will not be serviced by a temporary construction railway, but instead conveyors will be used for the transfer of materials from the TBM and out of the tunnel Rubber tyred vehicles will also be used for the transportation of material and people'". Certainty regarding the nature of transport to the TBM is critical to determine the likely impacts on the operation of sensitive impacts and the duration of potential disruptions due to such movements.	As outlined in Section 6.4 of EIAR Appendix A5.13 Tunnelling report, rubber tyre bi-directional multi-purpose vehicles will used for the primary transport and haulage activities in the tunnels to feed the TBM.
36	3.1 omissions and Errors in the EIAR Assessments	17	• There are significant deficiencies in the numerical modelling presented in the EIAR. The vibration modelling demonstrated that the predictions are very heavily dependent on the assumed ground stiffness parameters and the track isolation assumptions. Using the parameter values assumed in the EIAR, the modelling predicted vibration to be low. However, there is uncertainty in the ground properties assumptions, for which small differences in the assumed values have a large effect on the predicted vibration, particularly at low frequencies	TCD outlined a position where there is uncertainty in the ground conditions which would affect the input assumptions in the models prepared. TII refute this position and can identify that the project has excellent information on the ground conditions and are satisfied that the ground stiffness parameters are accurate. TII have utilised the services of Rupert Thornley Taylor, one of the leading groundborne noise & vibration specialists in the world to prepare the models for this work. Rupert has identified that the project has excellent information on the ground conditions and is satisfied that the ground stiffness parameters used are accurate. The assumptions used in the modelling are based on measured parameters from the construction of the Mater retaining wall for "Old Metro North".

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37	3.1 omissions and Errors in the EIAR Assessments	17	•The floating slab track proposed as mitigation in the EIAR assumed a very low spring stiffness, which leads to an unsuitable track design solution due to the deflection that would occur under the static loading of the train. To control the static track deflection, springs with higher stiffness would be more typically used. Modelling with higher spring stiffness, leads to higher predicted vibration and hence greater risk to Trinity's equipment. Furthermore, modelling by Arup indicates that the combination of booted sleepers and a floating slab track may make the vibration impacts on Trinity's sensitive equipment worse than an optimised floating slab design alone.	The floating slab track system is the best system to mitigate low frequency vibration and allows a compromise between low frequency attenuation and track deflection to be adopted. Please note that the proposed "Gerb" floating slab track has been widely used around the world with examples with low spring stiffness including the Elizabeth Line (Cross Rail) (7hz), Beijing Metro Line 4 (6 - 7 Hz), Beijing Metro Line 10 (6.5 - 8.0 Hz), Beijing Metro Line 13 (5.0 - 6.5 Hz), Shenzen Metro Line 1 (5 - 8.5hz), Tramway Bielefeld, Germany (5Hz), Tramway Cologne (6.5 Hz), Frankfurt/Main/International Airport (5hz), Stutgart-Ruit (5.7 Hz), Oslo Wessels Plass (5 Hz) and the Thomson-East Coast Line in Singapore. Modelling undertaken for the MetroLink project do not identify a signficant difference between the VC levels achieved using "Gerb springs" i.e floating slab track with booted block when compared to floating slab track with resilient base plates.

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38	3.1 omissions and Errors in the EIAR Assessments	17	• Having regard to EMI, EIAR Table 12.14 assumes that all SEMs have same performance requirement of 0.1pT p-p. However, the Zeiss Sigma Installation Requirements (2019) supplied by Panoz technical lead on 5 August 2020, state a requirement of 0.05pT p-p. There are also differences in the performance requirements for the SQUID.	The stated sensitivity utilised in the EIAR is 0.1 µT as opposed to 0.1 pT. The initial equipment list submitted for the Panoz Building cited three SEMs. These were identified to be 1. Room B-23 containing an SEM (model: Zeiss Supra 35VP) 2. Room B-24 containing an SEM (model: Tescan Mira3 Tiger 3. Room B-28 containing an SEM (model: Tescan S8000) A note from discussions with TCD suggested they were planning to replace the Zeiss Supra 35VP with a Zeiss Sigma 300 (a more sensitive piece of equipment) but it was not installed on the site at the time of our visit and field testing. The impact assessment was performed based on what was understood to be the equipment in the Panoz at the time of the assessment. The installation (whether already installed or at a later date) of a Zeiss Sigma 300 with its lower sensitivity threshold would need mitigation regardless of whether or not the proposed project goes ahead due to its sensitivity of 0.05 pT p-p. This would typically be in the form of shielding. For comparison, the current baseline within the Panoz was measured to be 0.15 µT (i.e. 150,000 pT) which is well in excess of 0.05 pT. Other equipment identified and considered for TCD, that is not discussed in the main chapter, is detailed in EIAR Appendix A12.2. For example, the STMs within CRANN which were determined to not be at risk of impact from the proposed scheme but, at the request of TCD were subjected to simulated field testing. The simulated field testing detailed in EIAR Appendix A12.6 confirmed this assumption. It was noted that a future SEM was also listed for the CRANN building but the EIAR with respect to EMC only considered equipment that was installed on site at the time of the assessment. The SQUID was tested and noted not to experience interference at the modelled DC field levels as discussed in EIAR Appendix A12.2. This assessment was based on the Preferred Route Alignment as published at that time. This passed closer to the SQUID than the now proposed Project alignment submitted with the RO application, so the applied levels for that earlier assessment are slightly higher than what is now modelled for the revised alignment. The field simulation testing performed at the equipment is detailed in EIAR Appendix A12.6. If there are discrepancies in the stated sensitivity it would not be cause for concern due to the testing performed at the equipment which simulated worst-case field levels for the originally proposed alignment. It is also worth noting that the consultant for TCD has rated the predicted impact for the SQUID as Low Risk/Meet Criteria in Appendix C of the Respondent's submission. No additional vulnerable equipment has been listed in the submission Appendix C that would be considered at risk of impact from EMI from the proposed development with the exception of the Zeiss Sigma 300 noted above.

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39	3.1 omissions and Errors in the EIAR Assessments	17	• Significantly, the operational phase assessment of EMI carried out does not take into account the cumulative impact of the MetroLink and the baseline environment which will mean that conditions are likely to be worse than that assumed (so it is not a worst-case).	A cumulative impact assessment with the baseline with respect to EMI from the proposed development is not considered necessary for the proposed development. We believe the submission most likely refers to DC fields, with the baseline emissions from the DART interacting with those from the proposed development to generate a cumulative effect. The DART and the proposed alignment do not run parallel through the Trinity campus at the locations of the discussed equipment and therefore their field vectors would not be considered significantly additive. While it is possible for a small cumulative effect to occur, as the schemes are not completely perpendicular, in practice during operation of both schemes (MetroLink and DART) any cumulative effect would be significantly below those that have been modelled and presented in the EIAR which has looked at a worst-case operational condition on the proposed development i.e. maximum current draw on both lines and from a single substation at the one time (simultaneously).
40	3.2.1 Vibration	18	Groundborne Noise and Vibration impacts are only reported in the EIAR for a small number of Trinity's buildings, as noted above. The results presented in the EIAR do not reflect the range and extent of vibration sensitive locations and facilities that would potentially be affected by both construction and operation of MetroLink. In particular, no consideration is given to the Panoz Institute, the Lloyd Institute, CRANN or the Fitzgerald Building, all of which were identified to TII as sensitive receptors by Trinity.	The EIAR Chapter 14 Groundborne Noise and Vibration presents predictions from various sources of groundborne noise and vibration for a small number of receptors next to the alignment, with a larger number of receptors reported in the Appendix 14.5. The identification of the closest buildings and mitigation proposals for those buildings will result in the removal of potential adverse impacts for buildings that are further away from the tunnel route. The receptors reported within Chapter 14 were selected to be representative of the potential worst affected receptors closest to the tunnel alignment. For Trinity College, results are reported in EIAR Chapter 14 for the Moyne Institute, Chemistry Building and SNIAM building, which are located closer to the tunnel alignment than the Panoz Institute, the Lloyd Institute or CRANN building. These buildings are indicated in the following Figures: Figure 14.2 Groundborne Noise from Tunnel Boring Machine Figure 14.3 Vibration from Mechanical Excavation Figure 14.4 Blasting Contours of PPV Figure 14.5 Blasting Air Overpressure Contours Figure 14.6 Groundborne Noise from Operation

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41	3.2.1 Vibration	18	With regard to the Construction Phase, EIAR Table 14.32 identifies significant impacts in terms of predicted vibration at the Trinity buildings identified [Chemistry Building, SNIAM and the Moyne Institute] associated with the passage of the TBM.	Unfortunately, there are no effective methods available to reduce groundborne noise or vibration from TBMs at source. The principal mitigation measures aimed at minimising impacts are as follows: • Advance public consultation and stakeholder engagement can greatly reduce the significance of groundborne noise effects during construction, as building occupants would be prepared for the passage of the TBM and resultant elevated noise and vibration levels. • TII will accept and consider applications for additional measures on a case-by case basis, in accordance with its Noise and Vibration Mitigation Policy (see EIAR Appendix A14.6). • With regard to vibration effects on the use of sensitive equipment, there is potential to plan the passage of the TBM during weeks when critical use of the equipment can be avoided. The programme for the TBM will be planned by the contractor. Consultation will be undertaken with TCD as soon as this programme is available to ensure that sensitive research operations do not coincide with the passage of the TBM.
42	3.2.1 Vibration	18	There is inconsistency in the reported extent of the corridor potentially adversely impacted by vibration during construction of the tunnel. In one section it is stated that the corridor would be 100m either side of the tunnel and elsewhere 250m is stated. Furthermore, the 100m corridor is the same as that stated for the operational impacts. It is submitted that a wider corridor would be expected for tunnelling than from operation of the railway.	EIAR Chapter 14 Ground-borne Noise and Vibration, Table 14.14, identifies that there may be vibration and groundborne noise impacts within 100m of the tunnel during tunnel boring as the rationale for the assessment of tunnel boring. This is considered to be applicable to standard receptors. In relation to more sensitive receptors, in this Chapter, Section 14.4.1.7 Section AZ4 Northwood to Charlemont, discusses potential impacts from groundborne noise and vibration in the AZ4 section, where Trinity College is located. The final paragraph of this section identifies that there is a potential for sensitive equipment to be impacted by vibration from the Tunnel Boring Machine within a distance of 250m from the tunnel centreline.
43	3.2.1 Vibration	18	As outlined above, the description of the construction works (EIAR Chapter 5 MetroLink Construction Phase) does not describe how personnel and materials such as tunnel lining segments would be transported through the tunnel to the TBM. The EIAR vibration assessment, however, is based on the assumption that there would not be a temporary construction railway, but rubber tyre vehicles will be used instead. It is critical that clarity is provided on the manner by which personnel and materials will be transported as the provision of a temporary construction railway would result in significant potential impacts for an extended duration during the construction period.	See Response (35)

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44	3.2.1 Vibration	18	Furthermore, there is a risk that groundborne vibration from blasting works for Tara Street Station could exceed the vibration criteria for some sensitive equipment. This has not been reported in the EIAR and would need to be assessed before any such works to determine the impacts on Trinity's activities.	As stated in Response (20): Blasting during construction has been assessed within the EIAR, with predicted vibration levels from blasting given in the EIAR Chapter 14, Table 14.34, for locations that are in close proximity to blasting activities. As the TCD campus is well outside of the 1 mm/s contour from blasting, as shown in EIAR Figure 14.4, values for TCD buildings are not included in this table. With predicted levels of blasting of less than 1 mm/s no potential adverse impacts are anticipated from blasting at TCD buildings.
45	3.2.1 Vibration	18	Based on the foregoing it is considered that insufficient clarity has been provided to appropriately quantify potential construction phase impacts and the duration and magnitude of such impacts.	The potential impacts during the construction phase on TCD for Ground-borne Noise and Vibration are identified in Chapter 14 of the EIAR. Please refer to Table 14.49 where impacts are identified for representative buildings at TCD as being temporary and significant and associated with the advancement of the TBM only. See also Response (40).
46	3.2.1 Vibration	18	In respect of the Operational Phase, with the track system proposed elsewhere on the MetroLink, the EIAR identifies that there would be significant risk to Trinity's equipment from vibration.	This is not correct. The specific mitigation measures proposed for the alignment underneath TCD entail the usage of Gerb spring Floating Slab track which is not proposed elsewhere on the alignment. As such, operational modelling results for other sections of the route are not applicable to the TCD section.

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47	3.2.1 Vibration	18	As outlined, the EIAR only considers groundborne vibration at three locations [Chemistry Building, SNIAM and Moyne Institute], EIAR Table 14.46 predicts that the effect of groundborne vibration at these three locations will be 'significant'. However, assessments carried out by Arup determine that the extent of significant impacts will be much wider that reported in the EIAR. It is submitted that the EIAR does not adequately report on the full extent of potential impacts to sensitive receptors within Trinity. The Arup assessment concludes that there is significant risk that vibration will exceed assessment criteria for equipment located within the Panoz Institute, the Lloyd Institute, CRANN and the Fitzgerald Building, in addition to those identified in the EIAR. In particular, unacceptable risk was identified for equipment located within the Panoz Institute (2x Confocal Microscopes), CRANN (1x Stylus Profileometer) and the Fitzgerald Building (3x STM, 1x STM, 1x AGFM and 1x Optical Telescope).	The buildings presented in Table 14.46 of the EIAR Chapter 14 are representative example receptors of buildings containing sensitive equipment, and is not intended to be a comprehensive list of all sensitive buildings within TCD. EIAR Chapter 14 Section 14.5.2 discusses mitigation for the operational phase, and contains the following paragraph; “With regard to sensitive laboratory equipment, detailed building-specific numerical modelling will be required to establish the likely exceedance of equipment specifications, and to find the optimum specification for the track support system to minimise exceedances. Mitigation at the receptor for specific rooms within sensitive buildings in the form of the installation of base-isolated foundation slabs to support the equipment may also be required. As the specific sensitive equipment in use at TCD is expected to change between the time of this assessment and the opening of the proposed Project, close consultation should be undertaken between TII and TCD in relation to the specifically sensitive rooms.” In addition, the statement "Detailed design measures for specific rooms containing sensitive electronic equipment" in EIAR Chapter 14 Table 14.54 reinforces that mitigation will be considered at the detailed design stage for rooms within Trinity College that contain sensitive electronic equipment. This is a clear commitment that there will be detailed consultation with TCD to establish an updated list of sensitive equipment and locations within buildings and in order to design appropriate mitigation before opening of the proposed Project.
48	3.2.1 Vibration	19	Notwithstanding the deficiencies identified in the EIAR with regard to the identification of affected buildings and equipment, and the assessment of vibration impacts, the EIAR vibration assessment concludes that the identified impacts will be fully mitigated by track design and by local mitigation at the sensitive equipment, where needed	See Response (47).
49	3.22 EMI	19	The following equipment in Trinity has been identified as being at risk of negative impact from the MetroLink: •3 no. Scanning Electron Microscopes (SEM) in the Panoz Institute •3 no. Nuclear Magnetic Resonance (NMR) machines in Chemistry •2 no. Magnetic Resonance Imaging (MRI) machines in the Lloyd Institute •1 no. SQUID machine in Sami Nasr Institute of Advanced Materials (SNIAMS)	TII confirm that this list matches that provided in EIAR Appendix A7.10, Table 1.1.

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50	3.22 EMI	19	During the construction phase the impact from EMI on this sensitive equipment will be minimal. The EIAR proposes that Trinity's equipment that is also vibration sensitive will be turned off as the Tunnel Boring Machine (TBM) passes near to Trinity.	No response needed

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51	3.22 EMI	19	During the operational phase the EIAR predictions of emissions from the MetroLink are broadly consistent with Arup's assessment. However, the EIAR does not assess the cumulative effect of existing baseline environment and the additional emissions from MetroLink. In this regard, baseline fields (from survey) and MetroLink emissions (from modelling) considered together generate more EMI than the MetroLink emissions considered on their own: •The EIAR assessed MetroLink emissions only. On the basis of the modelled emissions, the SEMs and NMRs are at risk from interference and are predicted to not meet equipment performance requirements. •Arup's assessment of Baseline + MetroLink emissions concludes that MRIs, SEMs and NMRs are at risk from interference and are predicted to not meet equipment performance requirements. •Arup's assessment also concludes that the predicted EM fields at the location of the sensitive equipment will not meet the performance requirements for some of the equipment under the Trinity proposed Option 5 alignment, and additional mitigation will be required.	The first point has been discussed under Response (39) but in summary for a cumulative effect to occur the associated vectors from the sources of the perturbations would need to be in approximately the same direction for an additive cumulative effect to occur. The DC field perturbations associated with a train accelerating and drawing current are transient in nature and last only a matter of seconds. For a cumulative effect to occur a localised vector would need to be generated in parallel with that associated from the proposed development and occur coincident with the maximum current draw event from the proposed development. The EIAR assessed the SEMs and NMRs are susceptible while TCD's consultants assessment conclude that MRIs, SEMs and NMRs are. The main discrepancy here is that the inclusion of the MRIs are also being considered as not having their minimum performance requirements met. The MRIs were identified as at risk from DC magnetic field perturbations for the original proposed alignment (Option 0 discussed in EIAR Appendix A7.10, which was the earlier Emerging Preferred Route/Preferred Route alignment at that time). With the realignment as now included in the RO Application (referred to as Option 2 in Appendix A7.10), the modelled levels for this option were reduced to a level below which it is expected that the MRIs will not be impacted (worst-case levels of 0.7 µT modelled as detailed in EIAR Chapter 12 Table 12.14 and Appendix A7.10 Table 5). TCD's consultant concludes that the MRI performance requirements will still be exceeded as a result of accounting for a cumulative effect between the fields from the proposed development and the baseline. However, there will be no significant cumulative effect from DC fields due to the requirement for the worst-case scenario to occur at the same time as a significant vector occurring from another source with a vector that would add a net gain in the same direction as those from the proposed development. The equipment is sensitive to changes in the DC magnetic field and these changes occur in time. The modelled worst-case levels from the proposed development will not be enduring for a significant period, similar to those fluctuations that were measured over seconds as part of the baseline surveys conducted, the results of which are detailed in EIAR Appendix A12.1 and A12.2. TCD's consultants also conclude that the predicted EM fields at the location of the sensitive equipment will not meet the performance requirements for some of the equipment under the Trinity proposed Option 5 alignment, and additional mitigation will be required. If the Zeiss Sigma 300 SEM is in situ at the discussed location within the Banoz building, then this conclusion is correct. However, the stated

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			additional mitigation will be required. Accordingly, it is clear that significant additional information is necessary from the Applicant for the purpose of identifying and assessing the efficacy and practicality of proposed mitigation measures to protect sensitive equipment from EMI emissions accurately predicted on the basis of Baseline + MetroLink sources.	Zeiss Sigma 300 SEM is in situ at the discussed location within the Panoz building, then this conclusion is correct. However, the stated sensitivity levels for this equipment are already exceeded within the baseline conditions (see EIAR Appendix A12.2) within the Panoz building and so mitigation needs to be considered regardless of the operation of the proposed development. This SEM system, when installed, would require mitigation to protect against the current baseline (particularly interference from the DART line). This would most likely be in the form of Mu-Metal shielding. Any mitigation provided to prevent interference from the DART for this equipment will work just as effectively for potential interference from the proposed Metrolink. TCD has requested that additional information be supplied for the purpose of identifying and assessing the efficacy and practicality of proposed mitigation measures to protect sensitive equipment. Subject to agreement with TCD, TII are proposing to trial the ACS systems at the potentially affected equipment with the aim of providing TCD further evidence as to the effectiveness of this mitigation. [Text based on CEMAR CN-146 Active Cancellation Trials - Trinity College]. It is expected that the proposed mitigation will suffice for the identified equipment as discussed in EIAR Appendix A7.10 i.e. the use of active cancellation. Two additional points are worth noting at this stage. The first is that in the event of the system failing trials, other mitigation is possible such as passive shielding. The second is that, in operation, it may not be necessary to switch on the active cancellation system as, in practice, DC field perturbations at levels in excess of the current baseline of the stated equipment sensitivity may never occur.
52	3.3.1 Vibration	22	For the TBM, assuming a tunnelling rate of 7m per day and that the effects on sensitive equipment would be apparent up to 100m from the tunnel face as reported in the EIAR, disruption could be 29 no. days continuously (including both before and after the TBM passes). However, the EIAR also states that the affected corridor could extend to some 250m around the TBM which would increase the period during which the requirement for sensitive equipment is exceeded to 71 no. days. Slower rates of tunnelling would further extend the duration of the disruption. No programme is available but disturbance to Trinity could be expected for several months in the absence of any system to mitigate construction phase mitigation measures. To fully quantify the level of disruption to Trinity's activities clarification is required in respect of potential impacts on blasting, the manner by which personnel and equipment are transported to the TBM and the construction programme.	The TBM is expected to advance at approximately 70m per week in Limestone. This means that the TBM will be underneath the TCD campus for approximately 4.5 weeks. If a worst case scenario is assumed, that a piece of sensitive equipment is vulnerable to excessive noise and vibration when the TBM is within 250m of it, then for each piece of sensitive equipment there will be a maximum period of potential effect of 7 weeks (50 days). However this is expected to be very much a worst case scenario. Evidence from a recent TBM advancement in Sydney, Australia has identified that in a sandstone bedrock of a similar hardness to the Dublin limestone, groundborne vibration levels reduced by 80% over 7 days with the TBM advancing at a rate of just 40m per week. Indicative tunnel drive programme information is provided in EIAR Appendix A5.2,Construction programme Including Tunnel Elements with the detailed schedule planned on the rates stated herewith. Regarding blasting, see Response (44). For construction movements along the tunnel see Response (35).

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53	3.3.1 Vibration	22	To mitigate operational phase vibration impacts, a complex track support system is proposed in the EIAR. EIAR Section 14.5.2 describes mitigation of vibration at source (in the track system design) and at receptors and provides: ..... Arup's analysis indicates that the proposed track support system would assist in addressing some of the significant effects. However, there are several items of equipment generally not identified or assessed in the EIAR for which the relevant criteria would be exceeded, even with the implementation of the proposed track support system.	See Response (47).
54	3.3.1 Vibration	22	Allied to this, there remains a significant level of uncertainty about the predictions at low frequencies due to uncertainties and sensitivity of numerical modelling to assumptions about the ground properties. Furthermore, the track support system properties stated would result in a system for which deflection of the rails under the static load imposed by the train is likely to be considerably greater than what is normal or proven for floating slab track. No confirmation of the practicability of the proposed system is provided.	Please refer to Response (37) regarding "uncertainties in ground conditions". As communicated in previous meeting to TCD, TII are confident that this measure can work at this site to mitigate effects on the TCD equipment. This confidence is based on the expert opinion of our specialist (Rupert Thornley Taylor). In addition it should be noted that the proposed (Gerb Spring) floating slab track system has been used successfully in other Metro Systems around the world including on the Thomson-East Coast Line in Singapore.

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55	3.3.1 Vibration	22	EIAR Section 14.5.2 acknowledges that there are facilities within Trinity that will require detailed consideration in the design to comply with the equipment requirements. Furthermore, it acknowledges that there may be changes in equipment between the present and the opening of MetroLink that need to be considered and mitigated: *"With regard to sensitive laboratory equipment, detailed building-specific numerical modelling will be required to establish the likely exceedance of equipment specifications, and to find the optimum specification for the track support system to minimise exceedances. Mitigation at the receptor for specific rooms within sensitive buildings in the form of the installation of base-isolated foundation slabs to support the equipment may also be required. As the specific sensitive equipment in use at Trinity is expected to change between the time of this assessment and the opening of the proposed Project close consultation should be undertaken between TII and Trinity in relation to the specifically sensitive rooms." [Emphasis added]* The proposal in the EIAR to mitigate residual significant effects at the receptor (sensitive equipment) through the use of base-isolated foundation slabs is not practicable for all equipment and buildings, especially for locations where equipment is not on a ground floor or basement level slab. Even where this solution could be possible, construction would cause significant disruption to Trinity's activities. Furthermore, any future requirements for vibration sensitive equipment to be installed in the same facilities could also be compromised.	TII acknowledge that there is potential for some disruption during the installation of base-isolated foundation slabs for sensitive equipment. However such installations would improve the environment for any equipment, regardless of low level noise and vibration predicted from MetroLink. TII do not agree that it is not practicable to install these structures as these installations are common and standard. It is also important to note that if very sensitive equipment is located above ground floor level, it is already likely to be subject to elevated noise and vibration that would not be consistent with the limits set for such sensitive equipment .
56	3.3.2 EMI	23	EIAR Section 12.10.1 addresses construction phase mitigation for EMI and states: *"As part of mitigation measures for noise and vibration some of these (particularly in Trinity) will not be in operation as the TBM passes, reducing the likelihood of DC magnetic field interference to nil for those equipment types".* While it is understood that such measures are dictated by vibration mitigation requirements rather than EMI, it is considered that the practicality of such measures, given the size of the TBM and the duration it will take to pass, would be seriously detrimental to Trinity's activities.	TII acknowledge that there will be potential for disruption to activities using very sensitive equipment on the site during the progression of the TBM for the duration described in Response (52). However describing these impacts as "seriously detrimental to Trinity's activities" appears to be an overstatement of these short term impacts.

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57	3.3.2 EMI	23	Section 12.11 of the EIAR states: "With regards to DC magnetic field impacts on sensitive medical and scanning equipment such as those located in Trinity, the Rotunda and the Mater the following mitigation measures are available: •Relocation of effected [sic] equipment; •Installation of an active-cancellation system; and •Shielding of the labs/rooms using specialised material designed to attenuate magnetic fields. *"Active cancellation systems operate on the basis of responding to a changing magnetic field, whereby the system generates a counter field to cancel out fluctuations as they occur. The response time of such a system has been cited as a cause of concern by some of the technical experts at Trinity, in previous meetings, so if such a system were to be adopted then the speed of cancellation versus the equipment acquisition rate would need to be scrutinised, to the point of field testing the application for effectiveness. A final solution would be the installation of fixed shielding, a solution with which some of the departments and institutes at Trinity are already familiar." [Emphasis added]*	The available mitigation measures are detailed in EIAR Chapter 12, Electromagnetic Compatibility and Stray Current, Section 12.11. These are presented as an unordered list and not in an order of preference. It is recommended that use of Active Cancellation Systems is the solution adopted to mitigate static DC magnetic perturbations. The use of passive shielding would be the next preferred option before having to explore the relocation of potentially affected equipment. TCD have cited concern in relation to the response time to the deal with the speed of cancellation versus their own equipment operating speeds. TII's consultants CEI note that the bandwidth of an Active Cancellation system is of the order of kHz and capable of accounting for variations occurring at a rate of hundreds of Hz. Based off CEI experience and their discussions with manufacturers of Active Cancellation systems, these systems are purposely designed to deal with the quasi DC nature of electric rail systems and for protection of the research systems being discussed. The bandwidth is more than sufficient to cover a 50 Hz field for example. With the DC rail a rate of change of close to 0 Hz would be expected, so well within the capabilities of an Active Cancellation system. Active Cancellation systems have proven to be effective in other installations world-wide for these applications and there is no concern in relation to the system's response time or with bandwidth being an issue.
58	3.3.2 EMI	23	It is noted that relocation of sensitive equipment has been suggested as a mitigation option in the EIAR, but not examined in any detail. This mitigation approach is unacceptable given the level of disruption involved to Trinity, the absence of any alternative suitable on-campus locations, and the effective sterilisation of eastern portion of the Campus for future research opportunities.	The use of active cancellation, passive shielding or a combination of both would avoid the need to relocate the equipment, but relocation is always listed as a mitigation option in the event that the stakeholder does not wish to pursue the other suggested mitigation methods. Regarding sterilisation of the eastern part of the campus, see Responses (26) and (27).

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59	3.3.2 EMI	24	The Active Cancellation Systems (ACS) system referenced as a potential EIAR mitigation measure consists of a number of orthogonal coils typically located around the room where the sensitive equipment is located, with a magnetic field sensor placed beside the sensitive equipment. The coils are used to create varying magnetic fields which oppose any magnetic field fluctuations at the sensor location. This is the mitigation option preferred in the EIAR at the location of the sensitive equipment. For the proposed alignment the sensitive equipment performance requirements are exceeded at the location of the NMRs (Chemistry Building) and SEMs (Panoz Institute) when the emissions from the MetroLink are considered on their own. The assessment of baseline and MetroLink emission is consistent with the EIAR methodology set out in the EIAR Guidelines, and the omission of the baseline levels from the assessment of impacts gives rise to significant deficiencies in the assessment of predicted impacts and proposed mitigation measures.	The baseline was measured and impacts were assessed. Whilst it is true that cumulative effects with the baseline are not discussed in detail within the EIAR, this is because no additive effects are anticipated to occur in the baseline at the same instant of maximum current draw in worst-case conditions from the proposed development. During the operational phase, measurable AC fields within buildings will arise from localised sources such as electrical equipment and building wiring. Similarly for radiofrequency fields. There will be no impacts from these fields either in isolation or cumulatively. For the DC and near DC fields, for a cumulative effect to occur the associated vectors from the sources of the perturbations would need to be in approximately the same direction for an additive effect to occur. The DC field perturbations associated with a train accelerating and drawing current are transient in nature and last only a matter of seconds. For a cumulative effect to occur a localised vector would need to be generated in parallel with that associated from the proposed development and occur coincident with the worst-case maximum current draw event from the proposed development.
60	3.3.2 EMI	24	The EIAR presents ACS as a viable mitigation option at the location of the SEMs and the NMRs. There is no assessment provided in the EIAR of how the ACS systems would work with 3 no. SEMs located in close proximity to one another (in the same room), nor is there any consideration of the practicality of using an ACS with NMRs. Arup has been unable to find precedents, comparators or indeed proven manufacturer ACS products for mitigation of EMI for NMRs. In addition, the coils of the active cancellation system cannot be placed close to reinforcement bars or other large ferrous masses as this will reduce its effectiveness, this may be challenging in an existing building.	At the Neils Bohr Institute in Copenhagen there are several ACS systems installed, also with instances of the equipment being installed in the same room. There is no concern about proximity to reinforcement bars on the efficacy of the system. The main challenge for the NMRs is their own static magnetic field which could saturate a sensor located too close to their magnet. ACS loops are typically installed in a closed loop configuration to maximise their field cancelling capabilities. There is however the option of utilising the system in an open loop configuration. The effect of this is that the sensor is not saturated, while satisfactory performance is still achieved. A large magnitude cancellation field will not be required for the NMRs. An ACS system with the capability of cancelling a 50 µT field, for example in closed loop configuration, will only need to utilise a fraction of this maximum capacity (modelled worst-case levels for NMR are 1.9 µT as detailed in EIAR Appendix A7.10 and EIAR Chapter 12 Table 12.14), and so can be configured for use in an open loop configuration.

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61	3.3.2 EMI	24	The final EIAR mitigation measures considered, which appears to be a last resort if ACS is not effective, is passive shielding. This mitigation option involves installing a high permeability material such as metal on all 6 sides of the room or laboratory. Compared with ACS passive shielding is highly disruptive and very costly. This option is partially explored as a solution for the NMRs. However, the budget of €90,000 proposed in EIAR Appendix A7.10 is considered to be unrealistic.	The example cited and its related cost relates to the use of Silicone steel as opposed to Mu-metal. The statement is correct that a mu-metal shielded room would significantly exceed the stated estimated cost of €90,000 but this figure was in relation to the use of Silicone steel which is a more cost effective alternative option that can provide sufficient magnetic field attenuation where the performance level of Mu-metal is not required. It is understood that the submission cites concerns about the disruption caused by implementing passive shielding which requires a significant overhaul of the affected room. This is one of the reasons why Active Cancellation is the recommended solution adopted.
62	3.4 Residual Risk Associated with Proposed Alignment	24	Notwithstanding the EIAR mitigation measures identified, the EIAR concludes that residual risk, for both vibration and EMI, remains 'significant' for the three Trinity buildings assessed. EIAR Section 14.6 sets out the expected residual significant effects of groundborne noise and vibration. Section 14.6.1.1 states: ..... EIAR Table 14.49 provides that residual impacts associated with construction phase vibration remain significant at the three Trinity buildings considered. EIAR Section 14.6.2.2 addresses operational stage vibration and states: ..... EIAR Table 14.54 also concludes that residual impacts associated with operational phase vibration remains "significant" at the three Trinity buildings considered.	EIAR Section 14.6.1.1 and Table 14.49 relate to construction impacts and specifically the passage of the TBM for which vibration mitigation is noted as not possible, however the impact will be of short duration with mitigation noted as 'Advance public consultation and stakeholder engagement'. EIAR Section 14.6.2.2 and Table 14.54 relate to vibration impacts on highly sensitive laboratory equipment during operational of the metro, with proposed mitigation noted in Table 14.54.

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63	3.4 Residual Risk Associated with Proposed Alignment	25	The headway between trains is generally only around two minutes. If vibration from operation was to compromise the working environment, the time between trains would be insufficient for it to be practicable to carry out vibration sensitive activities during these short quiescent periods. As noted in Section 3.3.1, the practicality and the effectiveness of the EIAR outline mitigation measures do not provide an acceptable level of certainty that there will not be unacceptable vibration impacts	Mitigation measures will mean that train frequency is irrelevant. As outlined in Arup's analysis "the proposed track support system would assist in addressing some of the significant effects". In addition, "base-isolated foundation slabs to support the equipment" is a well-used and effective manner of further mitigating vibration where required. See also Responses (22) and (37).
64	3.4 Residual Risk Associated with Proposed Alignment	25	With regard to residual EMI impacts, EIAR Section 12.12 states: *"Locations within the Trinity, Rotunda and Mater Campuses where DC and quasi-DC magnetic field perturbations are at elevated levels from the operation of the proposed Project may not be suitable for the installation or relocation of equipment with sensitivities to these types of fields'.* Section 12.12 goes on to state: *"Despite applied mitigation measures to minimise the magnitude of stray current, it is an inevitable phenomenon associated with DC rail systems. Continued monitoring of the performance of the traction circuit with respect to current returns to the substation will be required."* As outlined, it is acknowledged that ACS systems are widely used with SEMs) and they have also been used with MRIs. However, it is Arup's understanding that ACS systems are not established technology for NMRs. Furthermore, it is considered that the location of multiple SEMs in the same room and installation in existing buildings may restrict the effectiveness and practicality of such systems. Given the level of uncertainty in the suitability and effectiveness of the mitigation measures proposed it is necessary that a trial of an ACS system is conducted at the location of the SEMs and that this informs the proposed EIAR mitigation strategy.	It is important to note that trials have been offered to TCD previously. Subject to agreement with TCD, TII are proposing to trial the ACS systems at the potentially affected equipment with the aim of providing TCD further evidence as to the effectiveness of this mitigation. See also Response (7) regarding existing proven use of ACS systems elsewhere.

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65	3.5 Inadequate Assessment of Alternative Alignments	25	Section 4.1 below presents a robust technical assessment of the Option 5 Alignment utilising the same criteria used in the EIAR consideration of alternative alignments under the Trinity Campus. The alternatives considered all pass beneath the sensitive buildings on the eastern side of Trinity's campus and represent minor variations on the alignment applied for. As illustrated on the table in Appendix C, even with comprehensive mitigation, none of these alignments can demonstrably and fully mitigate the likely significant impacts on Trinity's sensitive equipment. The EIAR is materially inadequate and qualitatively deficient in this regard.	See Responses (5) and (6). The EIAR assessment of alternative routes and justification for the proposed route past Trinity is considered by TII to be robust and neither inadequate nor deficient.
66	4.0 MITIGATION OF LIKELY SIGNIFICANT EFFECTS	26	Based on Arup's assessment of the proposed alignment, and the ineffectual nature of the mitigation measures proposed in the EIAR to protect the performance requirements of the affected equipment, the only effective mitigation strategy is based on the following elements: •Trinity's Proposed Mitigation Strategy: o Mitigation by design with a localised realignment of the line beneath the Campus, identified on Figure 1.1 as 'Alignment Option 5', moving the alignment 61.5 m westward of the current proposed alignment; and o Further detail and assessment provided by the Applicant, by way of response to a Request for Further Information, in respect of the Mitigation Measures proposed in the EIAR as supplemented in this submission by Trinity's experts, to demonstrate to the satisfaction of the Board (and Trinity) the efficacy and practicality of those measures based on robust survey data, monitoring, assessment, and evidence of successful comparators, based on the Option 5 Alignment.	See Responses (5) and (6).

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67	4.1 Alternative Route Alignment (Option 5)	26	The Assessment recommended that the then preferred alignment (Option 0) be amended to Option 2. Option 2 does offer some improvement over the original alignment (Option 0). However, the EIAR itself clearly states that this option still results in "significant" "negative" impacts on Trinity's educational and research facilities.	As explained in the EIAR Appendix A7.10, Option 2, the alignment now included in the RO submission, provides improved settlement and noise mitigation compared to Option 0 (the earlier Preferred Route alignment) whilst remaining compatible with design parameters along the alignment and is a significant improvement in terms of potential EMI/EMC effects during operation compared to Option 0. With regard to operational noise and vibration, Option 2 would require some additional mitigation at track to address the potential localised specific vibration issue at the SNIAM building equipment at TCD. With the proposed mitigation measures noted in the EIAR, TII are confident that significant impacts can be addressed and mitigated.
68	4.1 Alternative Route Alignment (Option 5)	26	As detailed in the Arup EMI and Vibrations Studies, the current proposed alignment, together with the significant uncertainty in respect of the effectiveness of the proposed mitigation measures, will result in significant adverse effects on Trinity's educational and research activities. The EIAR Consideration of Alternatives and the Arup assessments undertaken clearly establish that the movement of the proposed alignment westwards, which increases the separation between the MetroLink and the highly sensitive equipment research equipment, will assist in reducing the magnitude of impact during both the construction and operational phases.	See Responses (5) and (6).

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69	4.1 Alternative Route Alignment (Option 5)	27	The EIAR identifies two more westerly alternatives (Options 3 and 4) and states that these were not feasible and, accordingly, these options were dismissed without presenting any detailed assessment6. The stated reasons are provided in EIAR Appendix A7.10 and are summarised as follows: •Inadequate space proofing of the tunnel to accommodate the dynamic kinematic envelope of the train operating on a tighter radius •TBM steering difficulties operating on a tighter radius •Operational Speed restrictions leading to increased journey times •Non-compliance with MetroLink's Design Parameters •Wheel-Rail Interference The CECL Global Report submitted herewith (Appendix D) disagrees with the findings of the options study and considers that a more westerly route could be designed which would have negligible impact on the construction, functionality or operation of the railway. (Footnote: [6]It appears that TII has made a deliberate choice to prioritise the performance of the railway over the needs of TCD.)	The proposed Project alignment past the TCD campus incorporating a 350m radius curve is considered by TII to be the best compromise alignment to address TCD concerns and to ensure that the proposed Project is not operationally constrained. Further details are provided in Response (5) and below.
70	4.1 Alternative Route Alignment (Option 5)	27	The Report presents an alternative feasible alignment (Option 5) which would increase the separation between the MetroLink and the highly sensitive research equipment without having consequential impacts to the alignment beyond Tara Street and St. Stephen's Green stations. Option 5 requires the following changes to the preferred alignment proposed in the Draft Railway Order: •One-degree clockwise rotation of Tara St Station •Reducing the minimum design radius to 260m •Reducing the operational speed to 60 km/h This alternative alignment is not a unique solution and other permutations of these types of changes may be used to achieve the same goal.	Refer to Response (5) for justification of the proposed Project alignment which TII consider is the best compromise to address TCD concerns whilst ensuring the proposed Project is not operationally constrained. In addition, Option 5, incorporating a slight rotation of Tara Street station, would require a tighter radius curve north of the station as well as that to the south, with additional impact on operational design speed and hence project economics.

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71	4.1 Alternative Route Alignment (Option 5)	27	The Applicant has rejected similar solutions in its options assessment based on a number of assumptions. The Report prepared by CECL Global includes the following summary which addresses these concerns and demonstrates that Option 5 as presented is a feasible alternative and which the Board is requested to require the Applicant to assess as part of a Request for Further Information:	See specific responses below (Responses (72) to (76)).
72	Table 4.1: Extract from CECL Global Report Addressing Specific Concerns with a more Westerly Alignment	28	**Inadequate space proofing of the tunnel to accommodate the dynamic kinematic envelope of the train operating on a tighter radius** *The dynamic kinematic envelope design for the tunnel considers the worst coexistent combination of horizontal and vertical curvature. The proposed horizontal alignment immediately South of Tara St. Station is relatively flat and therefore would not generate the same envelope. We therefore contend that sufficient space exists to accommodate the Trinity Westerly alignment.*	As noted in Response (5) there are other issues with options with a radius less than 350m (as proposed in the TCD Option 5) that need to be considered. For the particular issue regarding space proofing, at this stage of design it is normal to consider the worst case of horizontal and vertical curvature to retain flexibility for later design stages when more information on specific tunnel infrastructure and rolling stock characteristics are known. To locally adopt more stringent design constraints at this stage would increase project risks for the later stages of design development. Being able to ensure that the tunnels will acommodate the necessary train size assumed for MetroLink is very important. Of relevance is the recent issue on Spain's rail network where new trains were specified which turned out to be too large for some tunnels, an error identified in January 2023, 'Spain has spent €258 million on trains that are too big to fit in its rail network's tunnels' (see https://www.euronews.com/travel/2023/02/21/unspeakable-botch-spain-spends-258-million-on-trains-that-are-too-big-for-its-tunnels).

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73	Table 4.1: Extract from CECL Global Report Addressing Specific Concerns with a more Westerly Alignment	28	**TBM steering difficulties operating on a tighter radius** *We have assessed that a tunnel radius as small as 225m (i.e. significantly smaller than we propose) would have no impact on the ability to steer the tunnelling machine or to maintain efficient logistical backup. The tunnel ring, TBM and logistics would simply be designed for this minimum radius. In the zone beneath Trinity, a full face of homogeneous competent Argillaceous Limestone rock is expected which should provide excellent conditions for steering the tunnelling machine.* *A significant length of tunnel will have already been built by the time the TBM drives beneath Trinity and issues relating to learning curve will therefore have long since passed.*	It is acknowledged that the TBM could be designed to accommodate a tighter radius curve as proposed by TCD, although wider consultations with Jacobs/Idom, an independent TBM specialist and Herrenknecht as a major TBM supplier all indicate that a minimum 500m curve is generally recommended where possible for optimum delivery. TBM requirements to accommodate the proposed tighter radius curves as proposed by TCD would be expected to incur a small cost increase compared to the proposed Project requirements, due to likely change in ring design at this location, associated slight reduction in output around the curve, and changes to the TBM design to accommodate the drive through this specific location. However, the suggested tighter radius is not considered appropriate for other reasons and the proposed Project has only 3 locations where curves of radius less than 400m are adopted: - a 350m curve south of Griffith Park station, where the alignment is constrained by adjacent station locations - 350m and 375m reverse curves between O'Connell Street and Tara stations, where the alignment is constrained by adjacent station locations; and - the 350m curve alignment past the TCD campus.
74	Table 4.1: Extract from CECL Global Report Addressing Specific Concerns with a more Westerly Alignment	28	**Operational Speed restrictions leading to increased journey times** *The new proposed alignment would require a modest reduction in operational speed which will result in a negligible increase in journey time. This however needs to be offset against an overall reduction in the length between the two stations which will reduce journey time. We calculate the net increase in journey time to be less than 1 second.*	The 302m horizontal radius curve requires the vehicle speed to be reduced to 60 km/h and the corresponding expected impact on journey time has been assessed. If a standard approach is taken (as recommended by TII), the speed limit is applied throughout the circular curve as well as the enter and exit transition curves. Maintaining the 60 km/h limit until the end of the south transition curve generates an additional time of +3.7s per direction. If one takes account of the fact that the south transition curve does not impact on how much the alignment can be pushed towards the west, then it can be lengthened to allow the train to accelerate to 80 km/h right after the point the end of the train leaves the circular curve. This shortens the total length limited to 60 km/h and therefore reduces the travel time faster, although it results in a non-standard asymmetrical curve with different transition curve lengths at the ends (same as the R=350m option). With this approach, the additional travel time is +2.12s NB and +2.17 SB or +4.29 additional time for the round trip. The reason for considering this second approach is to consider a solution which would minimise the travel time impact that could be achieved. While the margins on the face of it are small, 2.12s NB and 2.17s SB, the overall total lost benefit is estimated conservatively to be €600,000 per annum (see calculation below). Equating to a VOT (Value of Time) loss of €36M over a 60 year system life. An indicative assessment of the potential economic cost can be made as follows: • Additional round trip travel time due to speed constraint = 4.3seconds • Value of time assumed for urban commuter passengers; €44/hr= €0.0122/sec • Additional cost per round trip per passenger = 4.3*€0.0122 = €0.0524 • Total passengers/day approx. 90,000, say 50% commuters • Total lost benefit = 45000*€0.0524*252days say = approx. €600,000/annum.

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				NOTE: This calculation is based on purpose of travel being "work" for 50% commuters and the value of their time @ €44/hr. No allowance is made for the other 50% of travellers and their VOT. This economic impact far outweighs the expected installation cost of the proposed Active Cancellation mitigation measures. This would also remain the case for the TCD suggested time saving of 1 second.
75	Table 4.1: Extract from CECL Global Report Addressing Specific Concerns with a more Westerly Alignment	28	**Non-compliance with MetroLink's Design Parameters** *Inspection of the values used by the Designer reveals an exceptionally conservative approach to the design when compared with recognised European and international best practice. We therefore do not accept that compliance with MetroLink's "gold plated" design parameters should be viewed as a fixed constraint.*	In practice, worldwide, any railway or metro administration designs new railway lines or metro systems assuming the strict limits of EN 13803. In new infrastructure that involves a high investment and that will have an intense and extensive demand and use during a very long service life, high standards of safety, comfort and ease of operation and maintenance are defined and expected. For the proposed Project, the design parameters proposed are considered appropriate and are the same as adopted on other new GoA4 metro systems (e.g. Barcelona Linea 9, Naples, Santiago de Chile, Riyadh). See also Response (72).
76	Table 4.1: Extract from CECL Global Report Addressing Specific Concerns with a more Westerly Alignment	28	**Wheel-Rail Interference** *Wheel-rail interference would not normally be expected to be encountered on a properly maintained system above the minimum radius of 150m as recommended in the European Standard. We therefore also reject this argument against the Westerly alignment.*	Refer to Response (5).

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77	4.1 Alternative Route Alignment (Option 5)	29	The proposed Option 5 alignment constitutes a reasonable alternative that should be addressed in a substantive manner by the Applicant by way of a Request for Further Information. It is acknowledged that scope to move the alignment westwards, without consequential changes to the alignment north and south of Tara Street and St. Stephen's Green stations, is limited[7]. Accordingly, while movement westwards by itself may not fully mitigate EMI and Vibration impacts, it can materially reduce and minimise the magnitude of such impact and to reduce the reliance on untested mitigation measures. Significantly, Option 5 also has the benefit of substantially reducing the impact on Trinity's future research and development activities within the College Green campus, providing scope for new or upgraded equipment to be located within the currently affected buildings on the eastern part of the campus. (Foot note: [7] The consequences of the proposed Option 5 Alignment on lands beyond the Trinity Campus are considered to be limited and of a low order of magnitude, and can be assessed in a revised EIAR.)	Refer to Response (5)
78	4.1 Alternative Route Alignment (Option 5)	29	The EIAR identifies significant construction phase vibration impact associated with the TBM. Due to the rate of movement of the machine, and the distances at which impacts will be felt, while the proposed Option 5 is unlikely to fully mitigate the impacts associated with the TBM, it would assist in creating a greater separation distance and therefore considerably reduce the duration and magnitude of the construction phase impacts.	The reasons why the TCD Option 5 is not acceptable to TII, together with justification for the proposed Project, are presented in Response (5). Regarding construction phase vibration, see Responses (40) and (45).
79	4.1 Alternative Route Alignment (Option 5)	29	With regard to operational vibration impacts, the Arup Vibration Report identifies an improvement in the vibration risk associated with Option 5, compared to the EIAR preferred Option 2, as locating the tunnels as far west as practicable would, in conjunction with optimised floating slab track design, reduce the risks and need for additional local mitigation at Trinity's facilities. It is submitted to the Board that it is necessary for the EIAR to assess the potential of this proposed mitigation by design, coupled with verified in situ mitigation measures to be identified in the EIAR.	The reasons why the TCD Option 5 is not acceptable to TII, together with justification for the proposed Project, are presented in Response (5).

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80	4.1 Alternative Route Alignment (Option 5)	29	The Arup EMI Report assesses the potential of the Option 5 alignment to mitigate the negative impacts on sensitive equipment locations. The NMRs in Chemistry dictate the separation distance as they are predicted to be exposed to high emissions from MetroLink and also are relatively sensitive to EMI (compared to the MRIs and the SQUID) and that equipment doesn't have established mitigation. The additional monitoring proposed in Section 5.0 below is required to properly understand and establish the baseline conditions. This will inform the distance that the alignment needs to move westwards to meet the performance requirements. The Arup EMI Report concludes that "*it is only by further increasing the separation between the MetroLink and sensitive equipment that the performance of the research activities at TCD can be assured.*" The Report states that to meet the performance requirements for the NMRs: •Using the EIAR survey and predicted emissions, the alignment would need to move an additional 65m (Option 5) west of alignment Option 2, and •Using Arup survey and predicted emissions, the alignment would need to move an additional 175m west of alignment Option 2. This emphasises the magnitude of the challenge to effectively mitigate EMI impacts under the Option 2 as applied for.	Option 5 as presented by TCD has not been modelled by CEI. However, as is presented by TCD's consultant (see Appendix C of the submission) it would still present an EMI risk with levels in excess of the performance requirements for the NMRs and SEMs and therefore still require mitigation based on their own modelling. Option 2, the proposed Project alignment as has been presented in the EIAR, has had its worst-case levels modelled and, while they also exceed the performance requirements for the same equipment, the re-alignment has ensured that the original levels associated with Option 0 have been significantly reduced; so much so that it makes the implementation of an Active Cancellation System solution more straightforward to achieve. The rationale for additional monitoring (three weeks as stated in Section 5 of the submission) is not understood. The monitoring performed to inform the EMI chapter of the EIAR was a snapshot of day to day levels. This snapshot was sufficient to establish that much of the sensitive equipment is already operating in an environment that exceeds their stated sensitives. Prolonging the monitoring period increases the window within which to measure field perturbations and therefore increases the chances of measuring levels that are further in excess of what was recorded during the short survey window previously utilised. It could lead to undermine TCD's case if the equipment is already operating in an environment further in excess of the previously measured baseline levels and possibly in excess of the modelled worst-case levels for Option 2. Nonetheless, TII are happy to work with TCD to develop a monitoring regime that meets TCD's requirements.
81	4.1 Alternative Route Alignment (Option 5)	30	In this regard, Option 5 as presented in the CECL Global Report moves the alignment approximately 61.5m westward of Option 2. Based on the information available, this is the extent the alignment can be moved without giving rise to more substantial design changes to the balance of the alignment.	The reasons why the TCD Option 5 is not acceptable to TII, together with justification for the proposed Project, are presented in Response (5), with further details in Responses (72) to (76).

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82	4.1 Alternative Route Alignment (Option 5)	30	A spreadsheet is attached at Appendix C (and summarised at Table 4.2 below) to assist the Board in understanding the interactions between the sensitive equipment and receptors, the route alignment options and the proposed mitigation measures (subject to demonstrating efficacy). The Appendix identifies all sensitive equipment, the 'as submitted' route alignment with EIAR mitigation, the alternative route alignment options with mitigation, and alignment Option 5 with comprehensive and updated EIAR mitigation (subject to demonstrating efficacy). Table 4.2 below identifies all sensitive equipment, the 'as submitted' route alignment with EIAR mitigation, and alignment Option 5 with EIAR mitigation (subject to demonstrating efficacy by way of a Request for Further Information). The Table uses a colour coded system to identify the predicted EMI and vibration impact on all elements of sensitive equipment. The colour coding clearly demonstrates the increasing confidence in the efficacy of mitigation by design associated with the westward realignment, coupled with additional mitigation measures. In this regard, there is a demonstrable difference in respect of vibration impacts between the two options. This significant potential of this mitigation by design option clearly warrants its consideration by TII by way of a Request for Further Information. There is also a demonstrable improvement in the sensitive equipment impacted by EMI, noting that significant additional mitigation measures that are demonstrated to be effective and viable will be required for the NMR machines in Chemistry.	Refer to Responses (5) and (72) to (76) which describe the reasons why the proposed Project alignment is considered the most appropriate regarding both operational requirements and addressing potential environmental impacts. Whilst the TCD Option 5 would provide some additional mitigation at source, it would not fully mitigate all impacts (as assessed by TCD), so still requiring additional mitigation for EMI effects in a similar way to the proposed Project.
83	4.1 Alternative Route Alignment (Option 5)	32	On the basis of the foregoing, it is submitted that the only mitigation strategy that can provide an acceptable level of confidence is: 1. Alignment Option 5, and 2. Further detail/corroboration on the EIAR Mitigation Measures, and: 3. Arup's recommendations, subject to: o The Applicant demonstrating to the satisfaction of the Board that the combined realignment and mitigation measures will be effective and practicable in mitigating impacts and residual impacts to an acceptable level.	See Response (5)

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84	5.0 MITIGATION MEASURES - INADEQUACY OF INFORMATION	32	On the basis of the information presented above, it is evident that significant additional information is required in order to identify, describe and assess all likely significant direct and indirect impacts on all elements of sensitive equipment identified in this submission, that presents an evidence-based assessment of the magnitude of those impacts having regard to the baseline context, and includes proposals to mitigate those impacts to acceptable levels substantiated by appropriate data and analysis, and evidence of their successful use in comparable contexts. Accordingly, it is imperative that the Applicant is requested to provide significant further information for the following reasons: •To enable an assessment by the Board of the efficacy of proposed mitigation measures that are reasonable, feasible and can be implemented. •To clearly detail and articulate in the EIAR the proposed mitigation measures to which the Applicant is committing and will be obliged to implement at its own cost in the event that the project proceeds. •To clearly detail monitoring that will be undertaken by the Applicant for the duration of construction and operation, and further mitigation measures that may be necessary in the event that the mitigation measures are not effective. Accordingly, the Board is respectfully requested to issue a Request for Further Information.	TII fundamentally disagree with this assertion and instead consider the assessment presented in the EIAR to be appropriate for this stage of the project. TII have clearly presented the potential for significant effects at TCD in terms of both EMI/EMC and groundborne Noise & Vibration. Where these potential effects are identified, specific mitigation measures are outlined in the EIAR. TII also point out that they have engaged in significant consultation with TCD on the proposed mitigation measures where their effectiveness and where the queries raised here have been responded to. As outlined above in Response (7), Active Cancellation has been widely used as an effective mitigation measure for EMI/EMC. Furthermore, TII's specialists have demonstratable direct experience with this system (which has been presented to TCD). As stated in Response (64), subject to agreement with TCD, TII are proposing to trial the ACS systems at the potentially affected equipment with the aim of providing TCD further evidence as to the effectiveness of this mitigation. [Text based on CEMAR CN-146 Active Cancellation Trials - Trinity College] In terms of vibration, as identified in Response (37) the use of "Gerb spring" floating slab track has also been successfully implemented on Metro systems around the world including on the Elizabeth Line (Crossrail) in London.
85	5.1 Detail of Further Information Required	32	The Board is respectfully requested to issue a Request for Further Information that requires the applicant to submit the following information in respect of: A. All elements of sensitive equipment identified in Table 2.1 this submission. B. Route Option 2 (as submitted), and Route Option 5 (Alternative Alignment) as presented in this submission. The information required to undertake the necessary assessments, to specify mitigation measures and to demonstrate the efficacy and practicality of those measures, is summarised as follows:	Please refer to Response (5) which summarises the justification for Option 2 (as included in the proposed Project). In addition, as noted above, for the purposes of the EMI/EMC assessment (as presented in EIAR Chapter 12), all relevant equipment has already been assessed. In regard to Groundborne Noise & Vibration, the assessment (as presented in EIAR Chapter 14) presents an overall predicted analysis at each of the buildings on the campus and a specialist analysis of the Fitzgerald Building and Panoz building on equipment within those buildings which are considered to represent the worst case scenario locations at TCD. It should be noted that TII requested data from TCD on foundations and buildings for all buildings on the campus but received only details on these two buildings which restricted the level of analysis that could be undertaken at this stage. None-the-less, TII are confident that the analysis presented in the chapter represents analysis of the worst case receptors and that the proposed mitigation measures will be effective for all locations of sensitive equipment at TCD.

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86	5.1 Detail of Further Information Required	33	1. Confirmation and evidence that the track support system design is viable in terms of railway engineering design. In particular, detail is required in respect of the deflection of the track under the proposed design, and evidence as to how the proposed deflection is acceptable in terms of RAMS (reliability, availability, maintainability and safety).	TCD are requesting information that would not normally be provided at this stage of the project i.e. RAMS and specific detail on "the deflection of the track under the proposed design". However, to provide TCD with comfort about the applicability of the proposed solution, TII have engaged with track suppliers and have identified the wide scale use of floating slab track solutions to mitigate low frequency vibration but allow a compromise between low frequency attenuation and track deflection to be adopted. An example would be the use of "Gerb" floating slab track, which has been widely used around the world with examples with low spring stiffness including the Elizabeth Line (Cross Rail) (7hz), Beijing Metro Line 4 (6 - 7 Hz), Beijing Metro Line 10 (6.5 - 8.0 Hz), Beijing Metro Line 13 (5.0 - 6.5 Hz), Shenzen Metro Line 1 (5 - 8.5hz), Tramway Bielefeld, Germany (5Hz), Tramway Cologne (6.5 Hz), Frankfurt/Main/International Airport (5hz), Stutgart-Ruit (5.7 Hz), Oslo Wessels Plass (5 Hz) and on the Thomson-East Coast Line in Singapore.
87	5.1 Detail of Further Information Required	33	2. Confirmation and evidence of the predicted vibration levels and spectra at each item of sensitive equipment at Trinity as identified on Table 2.1 of this submission. Details must include the modelling input data used, including assumptions about the building structure.	TII cannot provide "predicted vibration levels and spectra at each item of sensitive equipment at Trinity" as presented in Table 2.1 as despite requests for data, TCD have not provided building data to allow such models be run for every piece of equipment. However, the worst case scenario buildings, closest to the alignment, have been assessed with mitigation measures identified that will effectively mitigate these most sensitive buildings. As noted in Response (37), the identification of the closest buildings and mitigation proposals for those buildings will result in the removal of potential adverse impacts for buildings that are further away from the tunnel route.

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88	5.1 Detail of Further Information Required	33	3. Confirmation and evidence that the predicted vibration levels and spectra at each item of sensitive equipment at Trinity as identified on Table 2.1 of this submission can be achieved by a track support system that is acceptable in terms of RAMS. Details must include the modelling input data used, including assumptions about the building structure	Please refer to Response (87) in regard to providing data for each equipment location. For information, the technical input data to the model is as follows. Proposed Metrolink track system: standard LVT system (LVT Standard) and high attenuation system (LVT HA) in sensitive areas as TCD section. The track system with which the model should be realised would be the LVT HA (see tables and graphics below response table). System definition: Dimensions: L x W [mm] Total weight (single rail support)* [kg] Preliminary global support stiffness** [MN/m] **Total weight = single concrete block + resilient components + standard fastening system* ***Preliminary global spring rate, incl. rail pad, rubber boot and block pad* LVT Standard: 676 x 300 100 9 LVT High Attenuation: 676 x 376 123 15 LVT HA 2 system allows obtaining attenuation values very similar to those obtained with a floating slab solution. A comparison in terms of attenuation between our LVT HA 2 system and a common floating slab system is shown on a separate tab in this spreadsheet. As outlined in Response (37), the "Gerb" floating slab system has been widely adopted across the world and is operating safely on multiple metro systems. A specific RAMS at this stage of the project in the context of the proposed floating slab track design is not appropriate, given the preliminary nature of the design. A full RAMS assessment of the slab track design will be undertaken based on final design proposals for the Metro prepared at subsequent design stages to ensure a safe system is adopted, which will also be subject to CRR approval.
89	5.1 Detail of Further Information Required	33	4. Appendix A14.4 provides details of the FINDWAVE software used for the vibration predictions. It does not, however, provide spectral results and information relating to the level of uncertainty or error in the predicted vibration that would occur at the receptors. Due to uncertainties particularly related to the dynamic properties of the ground and the response of the various buildings, there are inevitably limitations in the accuracy of any prediction method, particularly related to low frequency vibration. Accordingly, further information on the uncertainty/margins of error in the predictions is necessary to substantiate the assessments contained in the EIAR, and to provide a better understanding of the risk implications.	Refer to response (36).

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90	5.1 Detail of Further Information Required	33	5. Modelling evidence is required to demonstrate that the proposed combination of floating slab track and booted sleepers is the best solution and would successfully mitigate vibration in the full range of frequencies relevant to vibration sensitive equipment identified on Table 2.1. A sensitivity study is required to compare the outcomes of viable mitigation solutions, using a variety of combinations of floating slab track and sleeper isolation.	The proposed mitigation measures have already been modelled in the EIAR and, on this basis, residual impacts have been defined i.e. effects identified after the implementation of the proposed mitigation measures. As outlined in EIAR Chapter 13, the inclusion of "Gerb type" floating slab track would be effective at mitigating groundborne Noise and Vibration at most sensitive equipment locations. The modelling indicated that in the SNIAMS building, at the worst-case location, VC-E limits can be achieved, while for the Fitzgerald building, at the worst-case, VC-D limits can be achieved. It will only be at the most sensitive equipment that any additional mitigation measures will be required as outlined in the EIAR in order to meet the most onerous of limits (VC-E). TII are happy to work with TCD to work up the logistics of the installation of isolation systems on a room by room basis. TII do not agree that it is appropriate at this stage of the project to undertake a “sensitivity study” to compare the effectiveness of a various combinations of mitigation measures. However, TII are happy to work closely with TCD as the design develops further (post RO) to test the proposed design measures to further demonstrate to TCD the finalised design will be effective in mitigating the impacts.
91	5.1 Detail of Further Information Required	33	6. Where impacts cannot be demonstrated to be fully mitigated at source, further details are required to demonstrate how equipment can be isolated locally by the installation of isolated plinths or, for smaller items, isolation tables or resilient mounts. Each isolation system should be individually specified, with evidence presented to demonstrate effectiveness. Alternatively, it may be possible to combine insertion gain required for the track and equipment isolation.	It is important to note that in the majority of locations it is considered that the floating slab track proposals will be more than sufficient to mitigate adverse impacts at sensitive equipment. However as previously advised to TCD, TII are happy to work with TCD to identify specific requirements for the installation of isolation systems on a room by room basis if required. TII will work with TCD to design isolated plinths, isolation tables etc at the very limited number of locations where equipment is sensitive enough to require additional mitigation measures. However, the specification of the same can only be defined following further design development on the floating slab track design in the tunnel.
92	5.1 Detail of Further Information Required	33	7. Details of specific measures proposed, for all items of equipment which require local mitigation, should be provided, including evidence that the proposed solutions are effective and practicable.	Refer to Response (91).
93	5.1 Detail of Further Information Required	33	8. Details as to how the existing vibration conditions will be protected such that the MetroLink would not compromise Trinity's ability to expand and develop their facilities in the future.	As outlined in Section 14.4.2 of the EIAR, the assessment shows that criteria for sensitive equipment at TCD can be satisfied.

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94	5.1 Detail of Further Information Required	33	9. Additional detail on monitoring to demonstrate that the baseline environment will not be made worse than that currently enjoyed by Trinity, and detail on the manner in which agreed baselines are measured over an extended period of time, and at locations to be agreed between TII and Trinity.	TII are happy to work with TCD to develop a monitoring regime that meets TCD's requirements in advance of the construction phase of the project. As noted in EIAR Chapter 31 (Summaries of Route Wide Mitigation and Monitoring), mitigation and monitoring measures have been identified as environmental commitments and overarching requirements which shall avoid, reduce or offset potential impacts. Mitigation and monitoring measures have been identified as environmental commitments and overarching requirements which shall avoid, reduce or offset potential impacts. Mitigation measures have been proposed for all impacts resulting in a moderate significance or above. Furthermore, mitigation measures have also been proposed for some impacts with a lower significance where such measures are routinely applied (for example in the management of construction-related impacts) or where, based on professional judgement, there would be a material benefit to the receptor.
95	5.1 Detail of Further Information Required	33	10. Assessment of EMI monitoring is required to be undertaken. Three weeks of monitoring is required for EMI at the location of the NMRs identified on Table 2.1 of this submission.	The rationale for monitoring is described in Response (80).
96	5.1 Detail of Further Information Required	33	11. Proposals for a monitoring system (see example *link*) for longer term readings of the baseline EM fields are also required [state purpose].	The rationale for monitoring is described in Response (80).

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97	5.1 Detail of Further Information Required	34	12. Details of proposed mitigation proposals and evidence of their successful use in comparable contexts to demonstrate that EMI risks to all equipment identified on Table 2.1 of this submission can be minimised to an acceptable level. This should include evidence of ACS being successfully used for NMRs, SEMs (multiple SEMs in close proximity) and MRIs.	During a presentation to introduce the concept of Active Cancellation (03 March 2021), the following examples were cited: - Neils Bohr Institute, Copenhagen, Denmark (SEMs and TEMs). The installations within Neils Bohr Institute involved several systems with some operating in close proximity. - Qatar Science and Technology Park, Doha (SEMs and TEMs) - Francis Crick Institute, London (SEMs) - University of California Irvine Materials Research Institute, California (TEMs) – used in combination with shielded room - Royal Hospital Melbourne, Australia (Linac) - Ongoing The list as presented at the time focussed solely on projects in which CEI acted in some capacity. It omits examples for MRIs and NMRs which are requested within this submission. For MRIs, Active Cancellation Systems have been installed by the following suppliers of the systems: ETS-Lindgren (MRIs at St. Vincent's Hospital, Australia and other sites over 20 years in the USA and Internationally) ITEL (Victoria House in South Yarra) Muller BBM (Installations in Europe and China) Stefan Mayer Instruments (installations in Europe and North America) IDE (worldwide but predominant experience with train systems in Japan). It is worth noting that IDE claim that for their system the sensor can be installed within the MRI space. Evidence of the use of Active Cancellation Systems with NMRs is limited. NMRs have the same characteristic as MRIs that is assumed to be the main obstacle preventing the successful use of an ACS i.e. an extremely strong magnet. MRIs are closely related to NMR machines and are in fact an application of NMR. That these systems can be successfully installed for MRIs means the same should be the case for NMRs.
98	5.1 Detail of Further Information Required	34	13. Trinity is agreeable in principle to the Applicant undertaking a trial of an ACS at the location of the SEMs in Panoz, and for the results to be submitted to the Board.	As noted in Response (64), subject to agreement with TCD, TII are proposing to trial the ACS systems at the potentially affected equipment with the aim of providing TCD further evidence as to the effectiveness of this mitigation. However, it is submitted that the evidence in the EIAR and these responses is sufficient assurance for the purposes of the RO application to allow ABP to grant same.
99	5.1 Detail of Further Information Required	34	14. Additional detail and clarification of the type of ACS's proposed and an assessment of efficacy of the system for the purpose of mitigating effects on all sensitive equipment identified on Table 2.1 of this submission.	TCD are requesting significant additional information that is not normally required at this stage of the project i.e. in advance of getting a RO approval. However, as per Item 13 above, TII are ready to do testing at each relevant piece of equipment to demonstrate the effectiveness of ACS following the grant of the RO. The specific type and set up at each location can then be worked through between TII and TCD.

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100	6.0 CONCLUSION	34	The EIAR clearly identifies "significant" and "negative" impacts on Trinity's educational and research facilities. The EIAR acknowledges that the mitigation measures proposed in the design will not adequately protect the identified sensitive receptors. It is the opinion of Trinity's technical experts that the application fails to adequately identify, describe and assess the likely direct and indirect significant effects of the MetroLink project on Trinity. The EIAR has failed to assess and consider feasible alternatives to reduce the level of unacceptable impacts and the EIAR mitigation measures lack substantive validation by robust survey data, monitoring, assessment and evidence of successful comparators. The EIAR is materially inadequate and qualitatively deficient in this regard, with significant consequences for Trinity.	Refer to Response (2), (3), (7) and (62). Appendix A7.10 provides assessment of alternative options considered to address TCD concerns and details the mitigation measures proposed to address residual impacts.
101	6.0 CONCLUSION	34	The significant uncertainty in respect of the availability and efficacy of potential mitigation measures also has significant implications for the future provision, upgrade and enhancement of equipment and research programmes in the affected buildings. In this regard, the proposed alignment, together with the wholly inadequate mitigation measures identified, have significant potential to constrain or sterilise Trinity's existing and future core academic and research activities on the eastern part of its campus.	Refer to Response (4) and other detailed responses above where these concerns are addressed in a comprehensive manner.
102	6.0 CONCLUSION	34	Based on Arup's assessment of the proposed alignment, and the ineffective nature of the mitigation measures proposed in the EIAR to protect the performance requirements of the affected equipment, the only effective mitigation strategy is based on the following elements: o Mitigation by design with a localised realignment of the line beneath the Campus, identified on Figure 1.1 as 'Alignment Option 5', moving the alignment 61.5 m westward of the current proposed alignment; and o Further detail and assessment provided by the Applicant, by way of response to a Request for Further Information, in respect of the Mitigation Measures proposed in the EIAR as supplemented in this submission by Trinity's experts, to demonstrate to the satisfaction of the Board (and Trinity) the efficacy and practicality of those measures based on robust survey data, monitoring, assessment, and evidence of successful comparators, based on the Option 5 Alignment.	Refer to Response (5) regarding the TCD Option 5 and other detailed responses above where these concerns are addressed in a comprehensive manner.

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MetroLink - Railway (MetroLink - Estuary to Charlemont via Dublin Airport) Order 2022 Submission made on behalf of Trinity College Dublin ABP Ref.: NA29N.31472				
103	6.0 CONCLUSION	35	It is submitted that it is imperative that the Applicant provides the significant additional information in respect of proposed mitigation measures identified in this submission for the following reasons: 1. To enable an assessment by the Board of the efficacy of proposed mitigation measures that are reasonable, feasible and that can be implemented. 2. To clearly detail and articulate in the EIAR the proposed mitigation measures to which the Applicant is committing and will be obliged to implement at its own cost in the event that the project proceeds. 3. To clearly detail monitoring that will be undertaken by the Applicant for the duration of construction and operation phases, and further mitigation measures that may be necessary in the event that the mitigation measures are not effective.	See Response (12).
104	6.0 CONCLUSION	35	In the event that the Applicant fails to demonstrate that effective, proven mitigation measures can be implemented, then Trinity is left in the position where it requests that the Board refuses consent, or terminates the MetroLink at a point north of Trinity's Campus having regard to the likely significant adverse, permanent and unacceptable impacts on the University's sensitive equipment, its established and future research facilities, its students, researchers and staff, and its global status and funding.	Refer to Response (8) regarding termination of MetroLink north of Trinity College and other detailed responses above where mitigation measures and their efficacy are addressed in a comprehensive manner.
105	6.0 CONCLUSION	35	Given its support for the principle of the MetroLink project, Trinity respectfully requests that the Board presents the Applicant with a further opportunity to properly consider the likely significant direct and indirect effects on Trinity, and in particular adequate mitigation measures (including mitigation by design). Section 5 of this submission provides a basis for the Board to issue a Request for Further Information inviting the applicant to submit a revised EIAR, revised plans and all necessary assessments, in respect Trinity's Proposed Mitigation Strategy.	Please refer to responses above where these concerns are addressed in a comprehensive manner. Response (5) in particular addresses the alternative alignment put forward by TCD and the justification for retaining the TII submitted alignment past TCD as part of the RO Application.

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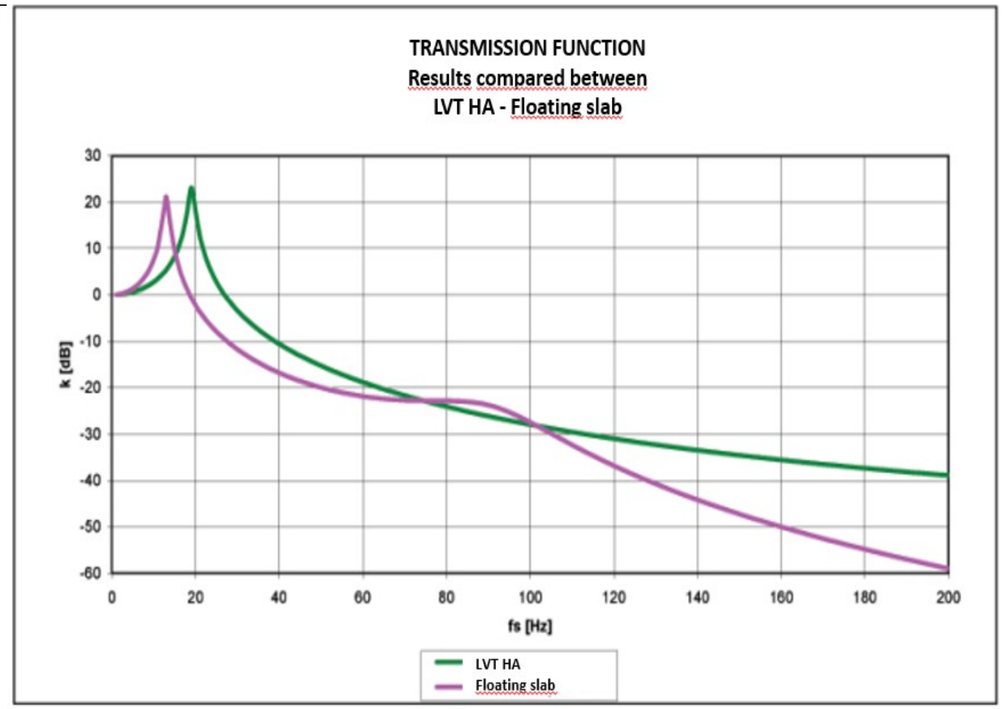
System	Dimensions L x W [mm]	Total weight (single rail support)* [kg]	Preliminary global support stiffness** [MN/m]
LVT Standard	676 x 300	100	9
LVT High Attenuation	676 x 376	123	15

**Total weight= single concrete block + resilient components + standard fastening system*

***Preliminary global spring rate, incl. rail pad, rubber boot and block pad*



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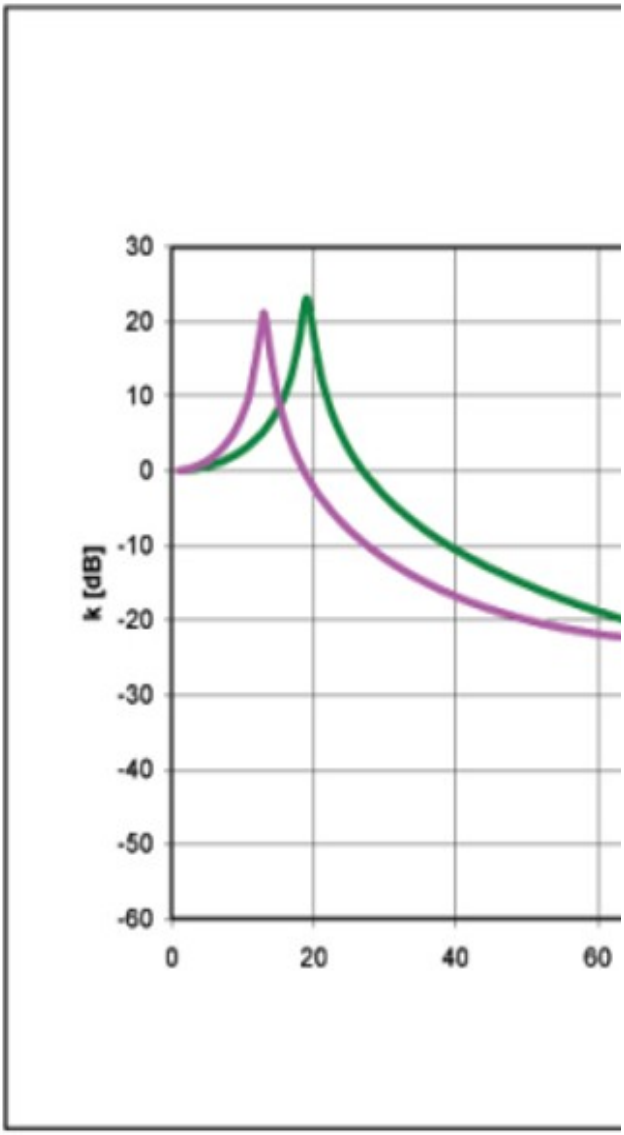

TRANSMISSION FUNCTION
Results compared between
LVT HA - Floating slab